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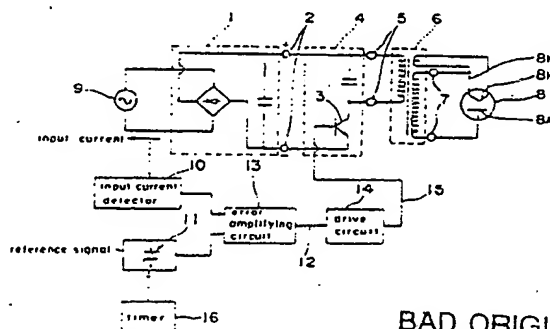
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(54) Magnetron feeding apparatus and method of controlling the same.

EP 0 289 032 A2 (57) A magnetron feeding apparatus and a method of controlling the magnetron feeding apparatus having an inverter circuit for converting the DC power supply into high-frequency power, a high-tension transformer for converting the high-frequency power into the high-tension power to be applied upon the magnetron, an output voltage detecting portion for detecting the output voltage of the high-tension transformer, an input current detecting portion for detecting the input current into the inverter circuit, a power controlling means for controlling the operation of the inverter circuit by the output voltage information of the output voltage detecting portion and the input current information of the input current detecting

portion.

Fig. 1



BAD ORIGINAL

BACKGROUND OF THE INVENTION

The present invention generally relates to improvements in a high-frequency heating apparatus for heating food, liquid or the like by a so-called dielectric heating such as electronic image or the like, and more particularly, to a magnetron feeding apparatus and a method of controlling the magnetron feeding apparatus which is adapted to effect a feeding operation to a magnetron by an inverter circuit using a semiconductor switch and a high-tension transformer.

Generally, a magnetron feeding apparatus shown in Fig. 1 is adapted to convert a DC current 2 from a power supply portion 1 into high-frequency power 5 by an inverter circuit 4 using a semiconductor switch 3 such as a transistor of the like, and furthermore to convert into high-tension power 7 by a high-tension transformer 6 to feed the power to a magnetron 8.

Also, a method of controlling the feeding power comprises steps of detecting the input current from a commercial power supply 9 by an input detecting portion 10, forming the difference information 12 between its value and the reference signal 11 by an error amplification circuit 13, a driving circuit 14 generates the driving pulse 15 corresponding to the difference information 12 to turn on, off the semiconductor switch 3, so that the input current is controlled to become a given value.

However, as most of the power to be fed to the magnetron 8 is consumed only by a heater 8_H before the magnetron 8 starts its oscillation, the power feeding operation will be approximately one-seventh of feed power at the steady-state time when the magnetron 8 is oscillating.

Namely, if the input current is controlled to the given value in a period before the magnetron 8 starts its oscillation, the excessive power is applied on the heater 8_H and also the excessive voltage is applied upon between the anode 8_A and the cathode 8_K , thus resulting in the life service of the magnetron 8 being shorter because of discharging, deteriorated insulation or the like.

The reference signal 11 is set to a value smaller at the steady-state time before the magnetron 8 starts its oscillation so as to be controlled to small input current which is proper to the heater heating operation. By the use of a timer 16, the reference signal 11 is switched to the value at the steady-state time after the lapse of the time sufficient enough for the magnetron 8 to start its oscillation, so that the input current may be controlled to a value at the steady-state time.

As time required for the oscillation to be started is two seconds when the magnetron 8 is kept warm, four seconds when it is kept cold, the time

for the timer 16 is set as five seconds for safety.

As the wave output of the magnetron 8 is hardly produced for five seconds, the wasteful time of $5-2=3$ seconds is consumed when the magnetron 8 is kept warm, while the wasteful time of $5-4=1$ second is consumed when the magnetron 8 is kept cold, with inconvenience that high-speed cooking capability which is characterized by the electronic range being deteriorated.

SUMMARY OF THE INVENTION

Accordingly, an essential object of the present invention is to provide a magnetron feeding apparatus, which is capable of controlling the output voltage of the high-tension transformer and the input current to the inverter circuit.

Another important object of the present invention is to provide a magnetron feeding apparatus which is capable of reaching so far as the oscillable condition of the magnetron within a shorter time, because large voltage, i.e., power as much as possible may be provided without application of excessive voltage upon the magnetron in a period before the magnetron starts its oscillation, namely, when the output voltage of the high-tension transformer is large in spite of small input current to the inverter circuit.

A further object of the present invention is to provide a magnetron feeding apparatus of the above-described type in which the controlling operation is effected so that the input current may be reached to the given value with the result that the starting operation may be effected without consumption of the wasteful time to the oscillating condition of the magnetron or the oscillating condition may be stably continued, because the input current to the inverter circuit is rapidly increased although the output voltage of the high-tension transformer becomes one second or lower with respect to the excessive voltage, with the magnetron becomes extremely low impedance load under constant application voltage when the oscillable condition is reached.

In accomplishing these and other objects, according to the preferred embodiments of the present invention, there is provided a magnetron feeding apparatus, which includes a power-supply portion for feeding DC current, an inverter circuit for converting the DC power supply into the high-frequency power by the switching operation of the semiconductor switch, a high-tension transformer for converting the high-frequency power into high-

tension power to be applied upon the magnetron, an output voltage detecting portion for detecting the output voltage of the high-tension transformer, an input current detecting portion for detecting the input current to the converter circuit, a power controlling means for controlling the switching operation of the semiconductor switch by the output voltage information of the output voltage detecting portion and the input current information of the input current detecting portion.

By the arrangement of the present invention as described above, an improved magnetron feeding apparatus removes the above-described wasteful time without lowering the service life of the magnetron.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram of a conventional magnetron feeding apparatus;

Fig. 2 is a construction conceptional diagram of a magnetron feeding apparatus of the present invention;

Fig. 3 is a block diagram in a first embodiment of an output voltage detecting portion;

Fig. 4 is a block diagram in a second embodiment of an output voltage detecting portion;

Fig. 5 is a block diagram in a first embodiment of a power supply portion;

Fig. 6 is a block diagram in a second embodiment of a power supply portion;

Fig. 7 is a block diagram in a first embodiment of an input current detecting portion;

Fig. 8 is a block diagram in a second embodiment of an input current detecting portion;

Fig. 9 shows a simple equivalent circuit of a magnetron;

Fig. 10 shows a characteristic graph of a magnetron;

Fig. 11 shows a characteristic graph of a magnetron feeding apparatus;

Fig. 12 is a block diagram in a first embodiment of a power controlling portion;

Fig. 13 shows a start characteristic graph of a magnetron feeding apparatus;

Fig. 14 is a block diagram in the other embodiment of a first reference signal generating circuit;

Fig. 15 is a block diagram of a first gradual increasing circuit;

Fig. 16 is a block diagram in the other embodiment of a power controlling portion which is partially changed in Fig. 13;

Fig. 17 is a characteristic graph thereof;

Fig. 18 is a block diagram in a second embodiment of a power controlling portion;

Fig. 19 is a block diagram in a third embodiment of a power controlling portion;

Fig. 20 is a characteristic graph of a magnetron apparatus in this case;

Fig. 21 is the other construction conventional diagram of a magnetron feeding apparatus;

Fig. 22 is a circuit block diagram of a magnetron feeding apparatus when the power controlling operation is performed by the software processing operation;

Fig. 23 is a conceptional diagram of a program flow of a software processing portion;

Fig. 25 is a flow chart in a second embodiment of a software processing portion; and

Fig. 26 is a flow chart in a third embodiment of a software processing portion.

DETAILED DESCRIPTION OF THE INVENTION

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

Referring now to the drawings, there is shown in Fig. 2 a magnetron feeding apparatus of the present invention, which includes a power supply portion 21 for feeding DC current 20, an inverter circuit 24 which switches in high frequency the DC power supply 20 by a semiconductor switch 22 to convert it into high-frequency power 23, a high-tension transformer 27 which converts the high-frequency power 23 into the high-tension power 26 necessary for the operation of a magnetron 25, an output voltage detecting portion 28 which detects the output voltage V_{OUT} of the high-tension transformer 27, an input current detecting portion 29 which detects the input current I_{IN} into the inverter circuit 24, a power control portion 33 for controlling the switching operation of an inverter circuit 24 through the outputting of driving pulses 32 which turn on, off the semiconductor switch 22 by the use of the output voltage information 30 of the output voltage detecting portion 28 and the input current information 31 of the input current detecting portion 29.

Fig. 3 is a construction diagram in a first embodiment of an output voltage detecting portion 28. Referring to Fig. 3, an exclusive detection winding 34 is provided on the output (secondary) side of the high-tension transformer 27, with the

output thereof being adapted to be outputted by the conversion into the output information 30' through a first rectification circuit 35. In such construction as described hereinabove, the output voltage information 30' corresponding to the output voltage V_{OUT} may be provided.

Fig. 4 is a construction diagram in a second embodiment out an output voltage detecting portion 28". Referring to Fig. 4, a detecting winding 36 which uses in combination one portion of the winding of the output (secondary) side of the high-tension transformer 27" is provided, with the output thereof being adapted to be outputted by the conversion into the output voltage information 30" corresponding to the output voltage V_{OUT} through a second rectification circuit 37.

As the operation voltage V_{AK} of the magnetron 25 is in such a polarity as the cathode 25_K becomes minus in electric potential with respect to anode 25_A, detection windings 34, 36, rectification circuits 35, 37 and output voltage information 30', 30" are polarized as shown in Fig. 3 and Fig. 4. For example, deformations may be made so that the detection windings 34, 36 and the rectification circuits 35, 37 are changed in polarity at the same time.

Fig. 5 is a construction diagram in a first embodiment of a power supply portion 21'. Referring to Fig. 5, the DC power supply 20' to be fed to the inverter circuit 24 is adapted to get commercial power 38 through a third rectification circuit 39.

Fig. 6 is a construction diagram showing a second embodiment of a power-supply portion 21". Referring to Fig. 6, DC current 20" to be fed to the inverter circuit 24 is adapted to be provided from a battery 40.

Fig. 7 is a block diagram showing the first embodiment of an input current detection portion 29'. Referring to Fig. 7, a current detection resistor 41 is inserted into between the power supply portion 21 and the inverter circuit 24 so as to convert the voltage to be caused across both the ends thereof into input current information 31' through a fourth rectification circuit 42 so that information corresponding to the input current I_{IN} may be inputted. It is needless to say that a current detection resistor 41 may be inserted onto the side of the pulse of the DC power supply 20.

Fig. 8 is a construction diagram showing the second embodiment of an input current detection portion 29". Referring to Fig. 8, the primary winding 43_P of a current detection transformer 43 is inserted into a commercial power supply 38 and a third rectification circuit 39 to convert the voltage to be caused in the secondary winding 43_S into the input current information 31" through a fifth rectification circuit 44 so that the information corresponding to the input current I_{IN} may be output-

ted.

A magnetron 25, which is a feeding object of a magnetron feeding apparatus of the present invention, will be described hereinafter.

Fig. 9 shows a single equivalent circuit of a magnetron 25. As shown in Fig. 9, equivalence between the anode 25_A and the cathode 25_K may be obtained by a resistor 25_R, a variable resistor 25_{V_R} and a Zener diode 25_{V_Z}. Also, the value of the variable resistor 25_{V_R} is changed through the heating operation of a heater 25_H. (V_R value during non-heating of the heater 25_H) / (V_R value during heating of the heater 25_H) becomes a value of 100 or more, so that the magnetron 25 oscillates the high frequency during the heating operation of the heater 25_H.

Accordingly, the relationship between the operating voltage : V_{AK} to be applied between the anode 25_A of the magnetron 25 and the cathode 25_K, and the operating current : I_{AK} becomes a load equivalent to the resistance of the high impedance when the magnetron 25 is not oscillated, and a load equivalent to a Zener diode of the low impedance when the magnetron 25 is oscillated as shown in the characteristic graph of Fig. 10.

Application of the voltage of $V_{AK} \geq 10_{KV0-P}$ deteriorates the insulation within the magnetron 25, causes discharges to considerably reduce the life service, with the maximum voltage being restricted to approximately in the present invention.

Fig. 11 is an input, output characteristic graph of the magnetron feeding apparatus showing the relationship between the input current : I_{IN} of an inverter circuit which feeds power to such a magnetron 25 and the output voltage V_{OUT} of the high-tension transformer.

In Fig. 11, when the magnetron 25 is not oscillated, the high impedance load through $V_{OUT} = 7_{KV0-P}$ is driven in $I_{IN} = 2_A$. When the magnetron 25 is oscillated, the low impedance load is driven under constant voltage which is hardly changed within V_{OUT} being 4_{KV0-P} in $I_{IN} = 2_A$ through 12_A .

Fig. 12 is a block diagram showing the first embodiment of a power control portion 33'. Referring to Fig. 12, a first diode circuit 45 inputs the larger information of the output voltage information 30 and the input current information 31 into a first error amplification circuit 46.

A first error amplification circuit 46 outputs a difference signal 48 between this input and the output of a first reference signal generating circuit 47. The first comparator 49 outputs a driving pulse 32' which turns on, off the semiconductor switch 22 by the difference signal 48 and a saw-tooth wave 51 from the first saw-tooth wave generating circuit 50 through a first comparator 49.

Also, the constant of each portion is set so that the input voltage information 30 in the output volt-

age $V_{OUT} = 7_{KV0-P}$ may conform to the output of a first reference signal generating circuit 47, and the input current information 31 in the input current : $I_{IN} = 12_A$ may conform to the output of a first reference signal generating circuit 47.

In a period before the magnetron 25 starts its oscillation by such construction as described hereinabove, the condition of the input current $I_{IN} = 2_A$ is established with respect to the output voltage $V_{OUT} = 7_{KV0-P}$. As the output voltage information 30 increased with decreases in the output of the first error amplification circuit 46, so that the on time of the driving pulse 32' decreases to lower the output voltage V_{OUT} . Inversely, when the output voltage information 30 decreases, the on time of the driving pulse 32' increases to make the output voltage V_{OUT} higher in a direction.

Also, in a condition where the magnetron 25 is oscillated, the condition of the output voltage $V_{AK} = 4_{KV0-P}$ is established with respect to the input current $I_{IN} = 12_A$. With increase in the input current information 31, the output in the first error amplification circuit 46 is reduced to decrease the on time of the driving pulse 32', so that the operation is effected in such a direction as to reduce the input current I_{IN} . Inversely, when the input current 31 is reduced, the on time of the driving pulse 32' is increased, so that the operation is effected in such a way as to increase the input current I_{IN} .

Fig. 13 is a starting characteristic graph of a magnetron feeding apparatus in such a controlled condition as described, wherein the output voltage V_{OUT} is controlled to 7_{KV} or lower and the input current I_{IN} is controlled to 12_A . Also, upon oscillation of the magnetron 25, the starting is immediately effected up to the steady state of the input current $I_{IN} = 12_A$ without the consumption of the time.

Also, in Fig. 12, such time constant as shown in Fig. 14 is used for the first reference signal generating circuit 47, with the output voltage V_{OUT} may be gradually increased up to 7_{KV} as shown in the dotted line A of Fig. 13.

Also, in Fig. 12, insert such a first gradual increasing circuit 52 as shown in Fig. 15 into between a first error amplification circuit 46 and a first comparator 49, the output voltage V_{OUT} and the input current I_{IN} may be gradually increased as shown in the dotted line A and the dotted line B of Fig. 13.

As shown in Fig. 16, by the use of the first gradual increasing circuit 52, a second reference signal generating circuit 53 equivalent to, for example 6_{KV0-P} in the output voltage V_{OUT} is 6_{KV0-P} or more, and it is turned on when the output voltage V_{OUT} is 6_{KV0-P} or lower, so that the input current I_{IN} may be gradually increased in the output voltage $V_{OUT} < 6_{KV0-P}$ as shown in Fig. 17.

Fig. 18 is a block diagram showing a second embodiment of a power control portion.

A second error amplification circuit 55 outputs a difference signal 57 between the output voltage information 30 and the reference signal of the third reference signal generating circuit 56 to the second diode circuit 58.

Similarly, a third error amplification circuit 59 outputs a difference signal 61 between the input current information 31 and the reference signal of a fourth reference signal generating circuit 60 to a second diode circuit 58. The second diode circuit 58 outputs to a third comparator 62 the smaller one of two difference signals 57, 61. The third comparator 62 outputs a driving pulse 32" which turns on, off the semiconductor switch 22 by the input and the sawtooth wave 64 from the second sawtooth wave generating circuit 63.

also, the constant of each portion is set so that the output voltage information 30 in the output voltage $V_{OUT} = 7_{KV0-P}$ may conform to the output of a third reference signal generating circuit 56, and the input current information 31 in the input current $I_{IN} = 12_A$ conforms to the output of a fourth reference signal generating circuit 60.

In such a period before the magnetron 25 starts its oscillation by such construction as described hereinabove, the required input current I_{IN} when the output voltage V_{OUT} is 7_{KV0-P} as shown in Fig. 11 is approximately 2_A , so that the difference signal 61 from the third error amplification circuit 59 becomes larger than the difference signal 57 from the second error amplification circuit 55.

Accordingly, in this period, the required input current I_{IN} less, i.e., the difference signal 57 from the second error amplification circuit 55 is selectively outputted by a second diode circuit 58. Thus, with increase in the output voltage information 30, the output of the second error amplification circuit 55 is decreased to reduce the on time of the driving pulse 32", so that the operation is effected in such a direction as to decrease the output voltage V_{OUT} . Inversely, when the output voltage information 30 is reduced, the on time of the driving pulse 32" increases so that the operation is operated in such a direction as to increase the output voltage V_{OUT} .

Also, in a condition where the magnetron 25 is oscillated, the output voltage V_{OUT} when the input current I_{IN} is approximately 4_{KV0-P} as shown in Fig. 11, so that the difference signal 57 from the second error amplification circuit 55 becomes larger than the difference signal 61 from the third error amplification circuit 59.

Accordingly, in this period, the required input current I_{IN} small, i.e., the difference signal from the third error amplification circuit 59 is selectively outputted by the diode circuit 58. Thus, with in-

crease in input current information 31, the output of the third error amplification 59 decreases to reduce the on time of the driving pulse 32", so that the operation is effected in such a direction as to reduce the input current I_{IN} . Inversely, the input current information 31 decreases, so that the operation is effected in such a way as to increase to make the input current I_{IN} more through the increase of the on time of the driving pulse 32".

Even in the second embodiment, the starting characteristics becomes the same as those of the starting characteristics graph of the first embodiment shown in Fig. 13.

Also, the third reference signal generating circuit 56 is constructed to have the time constant of the above-described Fig. 14, so that the controlling operation may be performed so as to gradually increase the output voltage V_{OUT} as far as 7_{KV} as shown in the dotted line A of Fig. 13.

Similarly, the first gradual increasing circuit 52 shown in Fig. 15 is inserted into between the second diode circuit 58 and the third comparator 62, so that the controlling operation may be controlled so as to gradually increase the output voltage V_{OUT} and the input current I_{IN} as in the dotted line A of Fig. 13 and the dotted line thereof.

In addition, the first gradual increasing circuit 52 is inserted into between the second diode circuit 58 and the third comparator 62. The first gradual increasing circuit 52 is turned on and off in accordance with the output voltage information 30 as shown in Fig. 16 to gradually increase the input current I_{IN} .

Fig. 19 is a block diagram showing the third embodiment of the power control portion 33". Referring to Fig. 19, the fourth error amplification circuit 65 outputs to the fourth comparator 69 the difference signal 68 between the referred signal from the fifth reference signal generating circuit 67 passing through the gradual increasing, gradual decreasing circuit 66, and the input current information 31. The fourth comparator 69 outputs the driving pulse 32" which switches on, off the semiconductor switch 22 through the difference signal 68 and the sawtooth wave 71 from the third sawtooth wave generating circuit 70.

Also, the constant of each portion is set so that the input current information 31 in the input current $I_{IN}=12_A$ may conform to the output of the fifth reference signal generating circuit 67.

Also, the fifth comparator 72 compares the output voltage information 30 with the output from the sixth reference signal generating circuit 73 corresponding to the output voltage information 30 in the output voltage $V_{OUT}=7_{KV\cdot p}$ to turn off the switch 72s when the output voltage V_{OUT} is smaller than $7_{KV\cdot p}$ so as to change the capacitor 66c through a resistor 66R₁ up to the output value of

the fifth reference signal generating circuit 67. Also, when the output voltage V_{OUT} becomes larger than $7_{KV\cdot p}$, the switch 72s is turned on to discharge the capacitor 66c through a resistor 66R₂ by a short time constant with respect to the changing.

When the output voltage V_{OUT} becomes larger than $7_{KV\cdot p}$ through the above-described construction in a period before the magnetron 25 starts its oscillation, the normal input of the fourth error gradual increasing circuit 65 is decreased, and the output of the difference signal 68 from the fourth error amplifying circuit 65 is decreased to reduce the on time of the driving pulse 32", so that the input current I_{IN} decreases to lower the output voltage V_{OUT} .

Inversely, when the output voltage V_{OUT} becomes smaller than $7_{KV\cdot p}$, the on time of the driving pulse 32" is increased, so that the operation is effected in a direction of increasing the output voltage V_{OUT} .

Also, in a condition where the magnetron 25 is oscillated, the output voltage V_{OUT} is approximately $4_{KV\cdot p}$, with the switch 72s being off.

Accordingly, the input current information 31 increases, the output of the fourth error amplification circuit 65 is decreased to reduce the on time of the driving pulse 32" so that the operation is effected in such a direction as to reduce the input current I_{IN} . Inversely, when the input current information 31 is decreased, the on time of the driving pulse 32" is decreased so that an operation is effected in such a way as to increase the input current I_{IN} .

Fig. 20 is a characteristic graph of a magnetron feeding apparatus in such a condition as described hereinabove.

As shown in Fig. 20, in a period before the magnetron 25 starts its oscillation, the output voltage V_{OUT} increases up to $7_{KV\cdot p}$, thereafter minutely vibrates around $7_{KV\cdot p}$ and the input current I_{IN} increases up to 12_A and then is controlled constant.

Fig. 21 is a construction conceptional diagram of a magnetron feeding apparatus when a high-tension rectification circuit 74 is inserted into between the high-tension transformer 27 and the magnetron 25.

Referring to Fig. 21, the sensitivity of the output voltage detecting portion 28 is required to be approximately doubled in increase as the output voltage V_{OUT} is different in value from the operative voltage V_{AK} , with the other constructions being provided without hindrance. Accordingly, the power control portion 33 may be realized in terms of the operation similar to the above-described operation even in a magnetron feeding apparatus equipped with a high-tension rectification circuit 74.

Fig. 22 is a circuit block diagram in a case where the power control of the magnetron feeding

apparatus is effected by the software processing.

Referring to Fig. 22, the software processing portion 75 inputs the input current information 31 from the input current detecting portion 29 and the output voltage information 30 from the output voltage detecting portion 28 to change the on time or the like of the driving pulse 32 which turns on, off the semiconductor switch 22 in accordance with the value of two information 30, 31 to perform the power control of the magnetron feeding apparatus.

An A/D converter, which is adapted to convert the input current information 31 and the output voltage information 30 into digital signals convenient for software processing, is used for the software processing portion 75, with the converting operation being omitted in the present application.

Fig. 23 is a conceptional diagram of a program flow of the software processing portion 75. Referring to Fig. 23, the power supply is turned on to perform the initial setting 76 for inner data or the like, thereafter to repeat the inputting operation 77 of the output voltage information 30 and the input current information 31, the production of the data for setting the on time to set the on time of the semiconductor switch by the use of this information the outputting operation 79 of the deriving pulse 32 for turning on, off the semiconductor switch 22 by the use of the data for setting the on time.

Fig. 24 is a flow chart showing the first embodiment of the software processing portion 75. Referring to Fig. 24, the RAM (on data) initial setting 80 is effected, to shorten the initial on time of the semiconductor switch 22, when the power supply is turned on. Then, the timer (on) start 81 for setting the on time of the semiconductor switch 22 is effected in accordance with the value of the RAM (on data) 90, so that the output 82 of the driving pulse (on) which turns on the semiconductor switch 22 is effected.

RAM (output voltage information) for inputting the output voltage information 30 — the output voltage information 83 and RAM (input current information) for inputting the input current information 31 — the input current 84 are performed. The two information is compared in RAM (output voltage information) > RAM (input current information) 85. The larger information is compared with the given value (A) 88 in RAM (output voltage information) > given value (A) 86 or RAM (input current information) > given value (A) 87. When the information is larger than the given value (A) 88, the RAM (on data) 90 is decreased by the RAM (on data) - given value (B) 89. When it is smaller than the given value (A) 88, the RAM (on data) 90 is increased by the RAM (on data) + given value (C) 91. Then, when the timer (on) completion 92 and the driving pulse (off) output 93 are performed to release the on condition of the semiconductor switch 22.

Then, after the off time of the semiconductor switch 22 has been controlled by the timer (off) start 94 and the timer (off) completion 95 to return to the timer (on) start 81.

By the processing as described hereinabove, the output voltage information 30 is larger than the input current information 31 in a period before the magnetron 25 starts its oscillation. When the RAM (output voltage information) 96 is larger than the given value (A) 88, the RAM (on data) 90 is decreased to make the on time of the semiconductor switch 22 shorter to reduce the output voltage V_{OUT} . Inversely, when the RAM (output voltage information) 96 is smaller than the given value (A) 88, the RAM (on data) 90 is increased to make the output voltage V_{OUT} more.

After the magnetron 25 starts its oscillation, the input current information 31 becomes larger than the output voltage information 30. The RAM (input current information) 87 is compared with the given value (A) 88 to increase or decrease the RAM (on data) 90 in accordance with the result so that an operation is effected so as to control the input current I_{IN} .

The large information of the output voltage information 30 and the input current information 31 is controlled to conform to the given value (A) 88. Also, the value size of the given value (B) 98 and the given value (C) 99 may vary the change speed of the increase, decrease of the output voltage V_{OUT} , the input current I_{IN} .

Fig. 25 is a flow chart showing the second embodiment of the software processing portion 75. Referring to Fig. 25, when the power supply is turned on, the initial setting 100 of the RAM (on data), RAM (on data V), RAM (on data I) is performed so as to shorten the initial on time of the semiconductor switch 22. Then, the timer (on) start 81 is effected to set the on time of the semiconductor switch 22 in accordance with the value of the RAM (on data) 90, so that the (on) output 82 of the driving pulse (on) which turns on the semiconductor switch 22 is effected.

The RAM (output voltage information) for inputting the output voltage information 30 — the output voltage information 83 is effected. The information is compared in RAM (output voltage information) > given value (D) 101. When it is larger than the given value (D) 102, the RAM (on data V) 104 is reduced in RAM (on data V) - given value (E) 103. When it is smaller than the given value (D) 102, the RAM (on data V) 104 is increased in RAM (on data V) + given value (F) 105.

Then, similarly, RAM (input current information) — input current information 84, RAM (input current information) > given value (G) 106, and RAM (on data I) - given value (H) 107 or RAM (on data I) + given value (I) 108 are effected.

Then, a comparing operation is performed in RAM (on data V) > RAM (on data I) 109. When RAM (on data V) 104 is smaller, RAM (on data) ← RAM (on data V) 110 is effected. When RAM (on data I) 111 is smaller, RAM (on data) ← RAM (on data I) 112 is effected.

Then, the timer (on) completion 92 and the driving pulse (off) output 83 are effected to release the on condition of the semiconductor switch 22.

Then, the off time of the semiconductor switch 22 is controlled by the timer (off) start 94 and the timer (off) completion 95 and thereafter it returns to the timer (on) start 81.

By such processing as described, the RAM (output voltage information) 96 approaches the given value (D) 102 in a period before the magnetron 25 starts its oscillation. Also, RAM (input current information) 97 < given value (G) 113, thus resulting in RAM (on data V) 104 < RAM (on data I) 111, with RAM (on data) 90 conforming in value to the RAM (on data V) 104.

Accordingly, in this period, when RAM (output voltage information) 96 is larger than the given value (D) 102, the RAM (on data V) 104 is decreased to make the on time of the semiconductor switch 22 shorter so as to reduce the output voltage V_{OUT} . Inversely, when it is smaller, the RAM (on data V) 104 is increased to make the output voltage V_{OUT} higher, so that the output voltage information 30 is controlled to conform to the given value (D) 102.

Also, after the magnetron 25 has started its oscillation, the RAM (input current information) 97 is approached to the given value 113, RAM (output voltage information) 96 < given value (D) 102, thus resulting in RAM (on data V) 104 > RAM (on data I) 111, with RAM (on data) 90 conforming to the RAM (on data I) 111.

Accordingly, in this period, the RAM (on data I) 111 is decreased when the RAM (input current information) 97 is larger than the given value (G) 113 to make the on time of the semiconductor switch 22 shorter so as to decrease the input current I_{IN} . Inversely, when it is smaller, RAM (on data I) 111 is increased to increase the input current I_{IN} , so that the input current information 31 is controlled to conform to the given value (G) 113. The processing that the value of the RAM (on data) 90 is set though the choice of the smaller of the RAM (on data V) 104 and the RAM (on data I) 111 results in the choice of the smaller one of the required input current I_{IN} . Also, the change speed of increase, decrease in the output voltage V_{OUT} may be varied by the given value (E) and the given value (F) 115, while the change speed of increase, decrease in the input current I_{IN} may be varied by the given value (H) 116 and the given value (I) 117.

Fig. 26 is a flow chart showing the third em-

bodiment of a software processing portion 75. Referring to Fig. 26, when the power supply is turned on, the initial setting 118 of the RAM (on data), RAM (current reference) is effected to shorten the first on time of the semiconductor switch 22. Then, the timer (on) start 81 is effected which sets the on time of the semiconductor switch 22 by the use of the RAM (on data) 90 to perform the outputting operation 82 of the driving pulse (on) which turns on the semiconductor switch 22.

The RAM (output voltage information) for inputting the output voltage information 30 ← the output voltage information 83 is effected.

This information is compared in RAM (output voltage information) > given value (J) 120, the RAM (current reference) 122 is decreased in RAM (current reference) - given value (K) 121. Inversely, when it is smaller than the given value (J) 120, the RAM (current reference) 122 is increased in (RAM current reference) + given value (L) 123. The maximum value of the RAM (current reference) 122 in this case is restricted to the given value (M) limit 124 of the RAM (current reference) 122.

Then, RAM (input current information) for inputting the current information 31 ← the input current information 84 is effected.

This information is compared with the RAM (input current information) > RAM (current reference) 126. When it is larger than the RAM (current reference) 122, the RAM (on data) 90 is decreased in the RAM (on data) - given value (N) 127. Inversely, when it is smaller, the RAM (on data) 90 is increased in RAM (on data) + given value (O) 128.

Then, the time (on) completion 92 and the driving pulse (off) output 93 are effected to release the on condition of the semiconductor switch 22.

Then, after the off time of the semiconductor switch 22 has been controlled by the timer (off) start 94 and the timer (off) completion 95, it is returned to the timer (on) start 81.

By such processing as described hereinabove, the RAM (output voltage information) 96 approaches the given value (J) 120 in a period before the magnetron 25 oscillates, with the RAM (current reference) 122 being not limited to the given value (M) 125.

When the RAM (output voltage information) 96 is larger than the given value (J) 120, the RAM (current reference) 122 is reduced, with the result that RAM (on data) 90 is reduced so that the RAM (input current information) 97 may follow the reduced RAM (current reference) 122. Accordingly, the on time of the semiconductor switch 22 is reduced to decrease the output voltage V_{OUT} and the input current I_{IN} . Inversely, when the RAM (output voltage information) 96 is smaller than the given value (J) 120, the RAM (on data) 90 is

increased and the output voltage V_{OUT} and the input current I_{IN} are increased.

The RAM (output voltage information) 96 is controlled to conform to the given value (J) 120 in this period.

Also, in a period after the magnetron 25 has started its oscillation, RAM (output voltage information) 96 \ll given value (J) 120, with RAM (current reference) 122 becoming the same in value as the given value (M) 125.

Accordingly, when the RAM (input current information) 97 is larger than the given value (M) 125, the RAM (on data) 90 is reduced to shorten the on time of the semiconductor switch 22 to reduce the input current I_{IN} . Inversely, when it is smaller, the RAM (on data) 90 is increased to make the input current I_{IN} more, so that RAM (input current information) 97 is controlled to conform to the given value (M) 125.

Also, the change speed of the increase, decrease of the output voltage V_{OUT} may be respectively varied by the given value (K) 129, the given value (L) 130, the given value (IV) 131, and the given value (O) 132. Also, the change speed of the increase, decrease of the input current I_{IN} is respectively varied by the given value (N) 131 and the given value (O).

In the magnetron feeding apparatus by the present invention, optimum voltage, power may be steadily fed in a period before the magnetron starts its oscillation, the possible oscillation condition of the magnetron may be reached in a short time without application of the excessive voltage.

Also, when the possible oscillation condition is reached, the condition automatically moves to the controlling operation may be effected without consumption of the wasteful time as far as the oscillating condition of the magnetron, and also, the oscillating condition may be steadily continued.

Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as included therein.

Claims

1. A magnetron feeding apparatus comprising a power-supply portion for feeding a DC current, an inverter circuit for converting the DC current into high-frequency power through the switching operation of a semiconductor switch, a high-tension transformer which converts the high-frequency power into high-tension power to be applied upon a

magnetron, an output voltage detection portion for detecting the output voltage of the high-tension transformer, an input current detecting portion for detecting the input current into the inverter circuit, a power controlling means for controlling the switching operation of the semiconductor switch by the use of the output voltage information of the output voltage detecting portion and the input current information of the input current detecting portion.

2. A magnetron feeding apparatus described in Claim 1, further comprising a power controlling means for controlling so that the value of the larger of the output voltage information and input current information may become a first given value.

3. A magnetron feeding apparatus described in Claim 1, wherein a power controlling means comprises an output voltage controlling means for controlling so that the output voltage information may become a second given value, an input current controlling means for controlling so that the input current information may become a third given value, a selecting means for selecting a controlling means of the smaller of the output voltage controlling means and the input current controlling means in the required input current into the inverter circuit.

4. A magnetron feeding apparatus described in Claim 1, wherein a power-supply portion is adapted to rectify the commercial power-supply to obtain the DC power supply.

5. A magnetron feeding apparatus described in Claim 1, wherein a power-supply portion is composed of a battery.

6. A magnetron feeding apparatus described in Claim 1, wherein an input current detecting portion is adapted to detect the input current from the power-supply portion.

7. A magnetron feeding apparatus described in Claim 1, wherein an output voltage detecting portion is adapted to detect the output voltage of the exclusive detection winding provided on the high-tension transformer.

8. A magnetron feeding apparatus described in Claim 1, wherein an output voltage detecting portion uses one portion of the output (secondary) side winding of the high-tension transformer as detection winding so as to detect the output voltage.

9. A magnetron feeding apparatus described in Claim 2, wherein a first gradual increasing means for controlling so that the output voltage information or the input current information is gradually increased to the power controlling means.

10. A magnetron feeding apparatus described in Claim 3, wherein a second gradual increasing means for controlling so that the output voltage information or the input current information may be gradually increased to the power controlling means.

11. A magnetron feeding apparatus described in Claim 1, further comprising a third comparing means for comparing the output voltage information with a sixth given value, a third gradual increasing means for controlling so that the input current information is gradually increased to a seventh given value when the output voltage information is small with respect to the sixth given value, a first gradual decreasing means for controlling so that the right current information may be gradually decreasing when the output voltage information is large with respect to the sixth given value.

12. A magnetron feeding apparatus described in Claim 4, wherein an input current detecting portion is adapted to detect the input current from the commercial power supply.

13. A magnetron feeding apparatus described in Claim 1, wherein a rectification circuit is inserted into between the high-tension transformer and the magnetron.

14. A magnetron feeding apparatus comprising a power-supply portion for feeding the DC current, an inverter circuit for converting the DC current into high-frequency power through the switching operation of a semiconductor switch, a high-tension transformer which converts the high-frequency power into high-tension power to be applied upon a magnetron, an output voltage detection portion for detecting the output voltage of the high-tension transformer, an input current detecting portion for detecting the input current into the inverter circuit, a software processing portion for forming the driving pulses of the semiconductor switch by the use of the output voltage information of the output voltage detecting portion and the input current information of the input current detecting portion.

15. A method of controlling a magnetron feeding apparatus described in Claim 14, having in a software processing portion a program flow comprising the steps of performing the initial setting of the inner data after the power supply has been put into work, thereafter repeating the inputting operation of the output voltage information and the input current information, the data forming operation for setting the on time to form, by the case of the inputted two information, the data for the on time setting use for setting the on time of the semiconductor switch, a driving pulse outputting operation for setting the pulse width of the driving pulse which turns on, off the semiconductor switch by the use of the data for the on time setting use.

16. A method of controlling a magnetron feeding apparatus described in Claim 15, having in a software processing portion a program flow comprising the steps of starting a timer (on) for setting the timer time at the value of the on time setting data, outputting driving pulses for turning on the semiconductor switch, detecting the completion of

the timer (on) to output driving pulses for turning off the semiconductor, starting the timer (off) of the timer time of the given value, returning to the start of the timer (on) through the detection of the completion of the timer (off).

17. A method of controlling a magnetic feeding apparatus described in Claim 15, having in a software processing portion a program flow comprising the steps of inputting the output voltage information and the input voltage information, selecting the information of the larger value through the comparison between both the of them, comparing the information of the larger value and the given value (A) to decrease the data for the on time setting use when the information is larger than the given value (A), increasing the data for on time setting use when it is smaller than the given value (A).

18. A method of controlling magnetron feeding apparatus described in Claim 15, having in a software processing portion program flow comprising the steps of inputting output voltage information, comparing the output voltage information with the given value (B) to decrease the data V for the on time setting use when it is larger than the given value (B), increasing the data V for the on time setting use when it is smaller than the given value (B), a program flow comprising the steps of inputting the input current information, comprising the input current information with the given value (C) to decrease the data I for the on time setting use when it is larger than the given value (C), increasing the data I for the on time setting use when it is smaller than the given value (C) and a program flow comprising the steps of comparing the data V for on time setting use with the data I for the on time setting use, having the data of smaller value as the data for the on time setting use.

19. A method of controlling a magnetron feeding apparatus described in Claim 15, having in a software processing portion a program flow comprising the steps of inputting the output voltage information, comprising the output voltage information with the given value (D) to decrease the current reference information when it is larger than the given value (D), to increase the current reference information when it is smaller than the given value (D), and restricting to the given value (E) the largest of the increased current reference information, a program flow comprising the steps of inputting the input current information, comparing the input current information with the current reference information to decrease the data for the on time setting use when it is larger than the current reference information, to increase the data for the on time setting use when it is smaller than the current reference information.

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Fig. 1

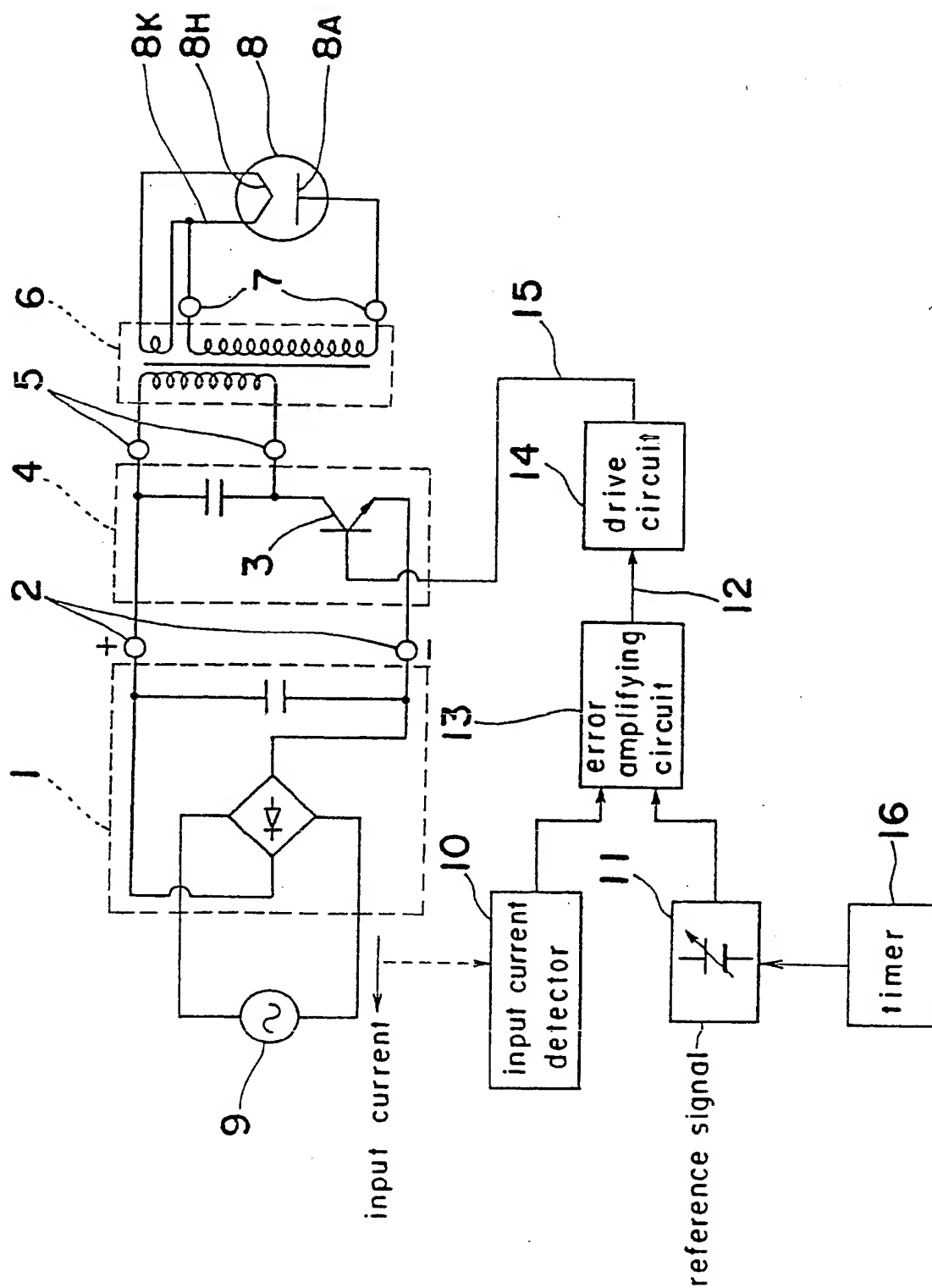


Fig. 2

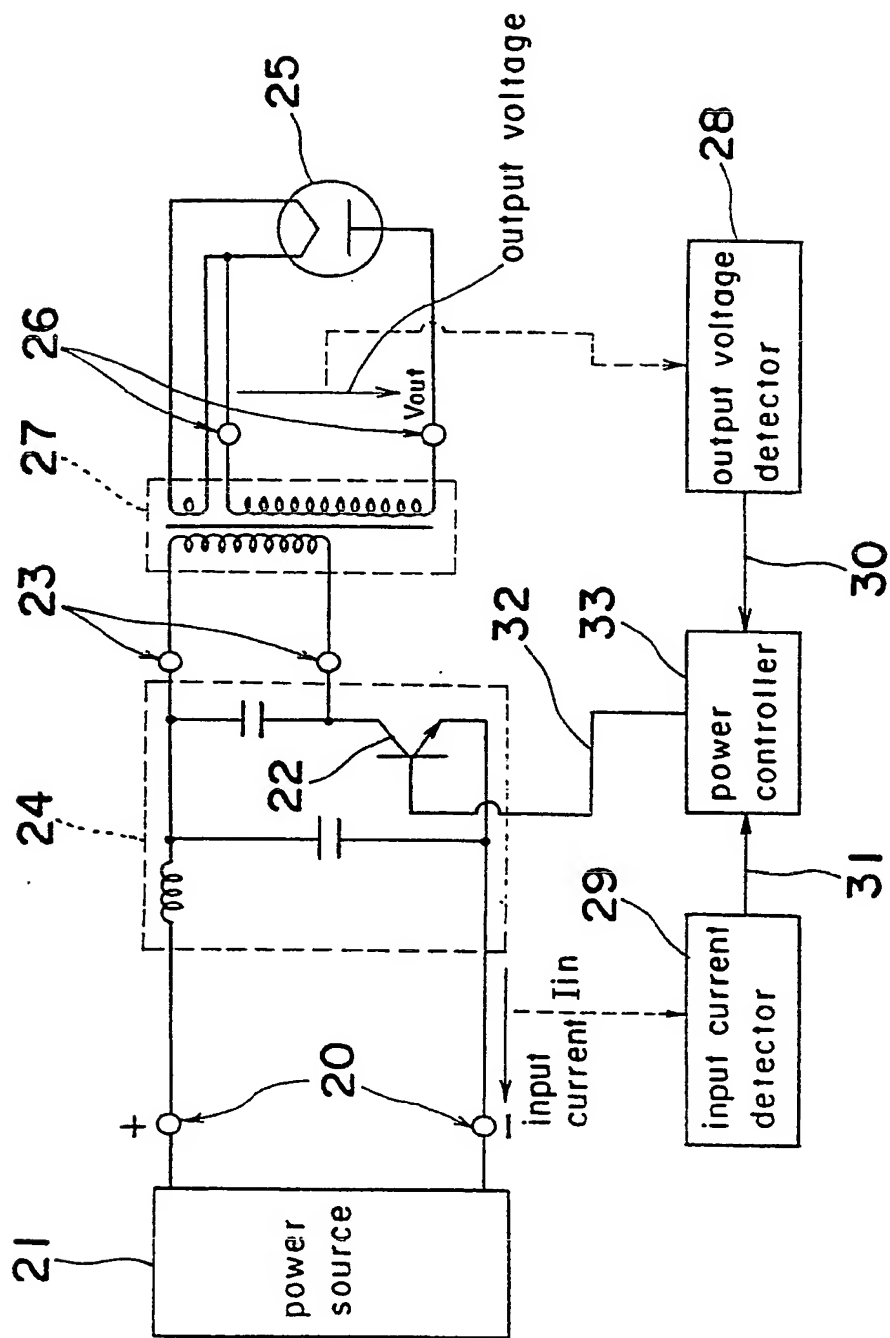


Fig. 3

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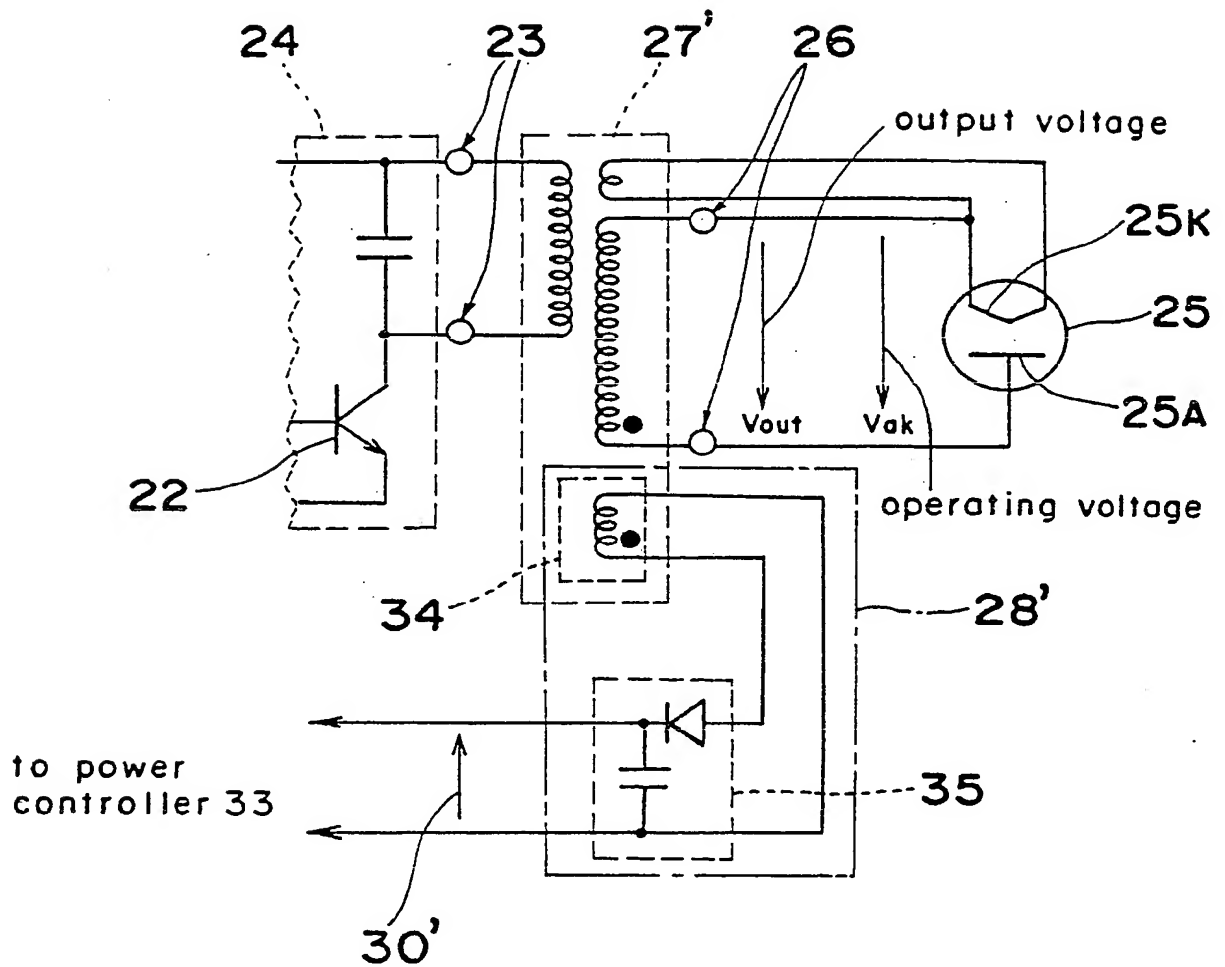


Fig. 6

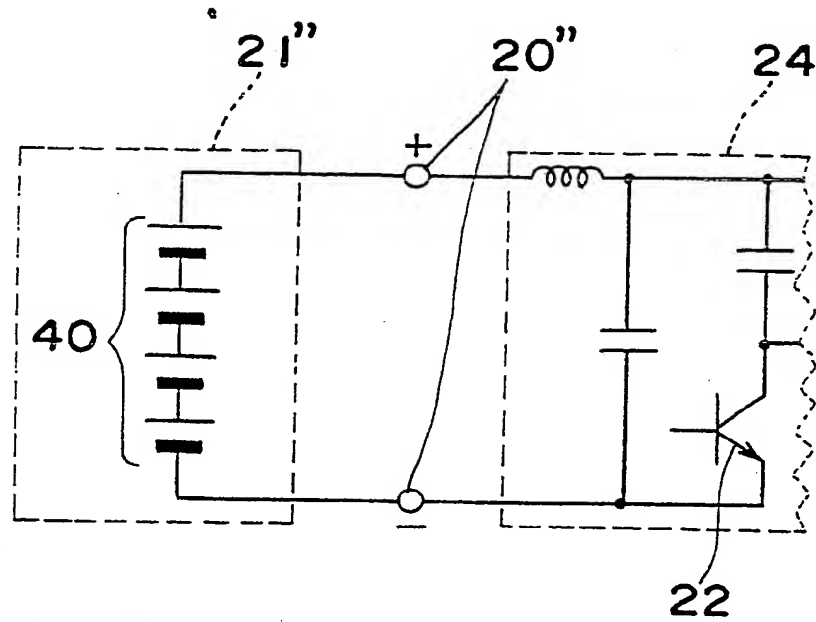
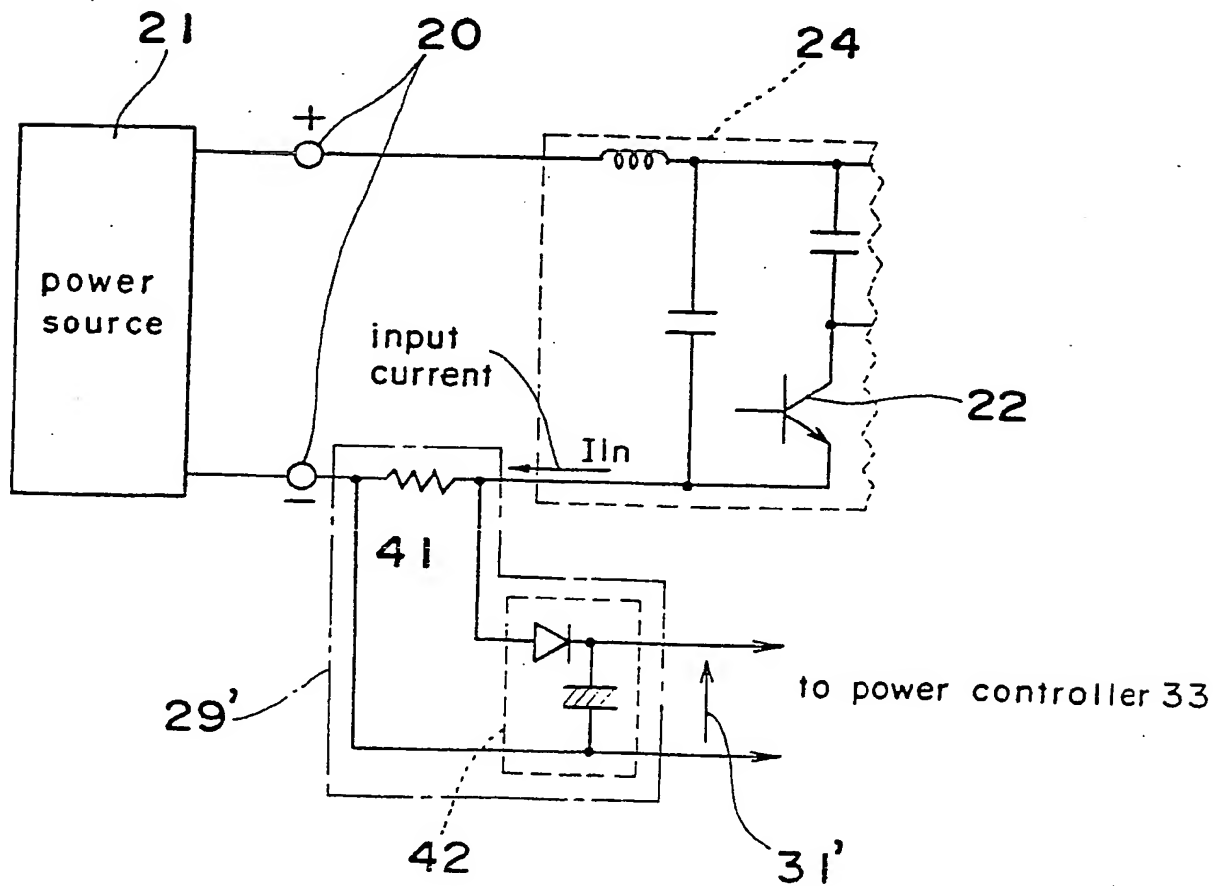


Fig. 7



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Fig. 8

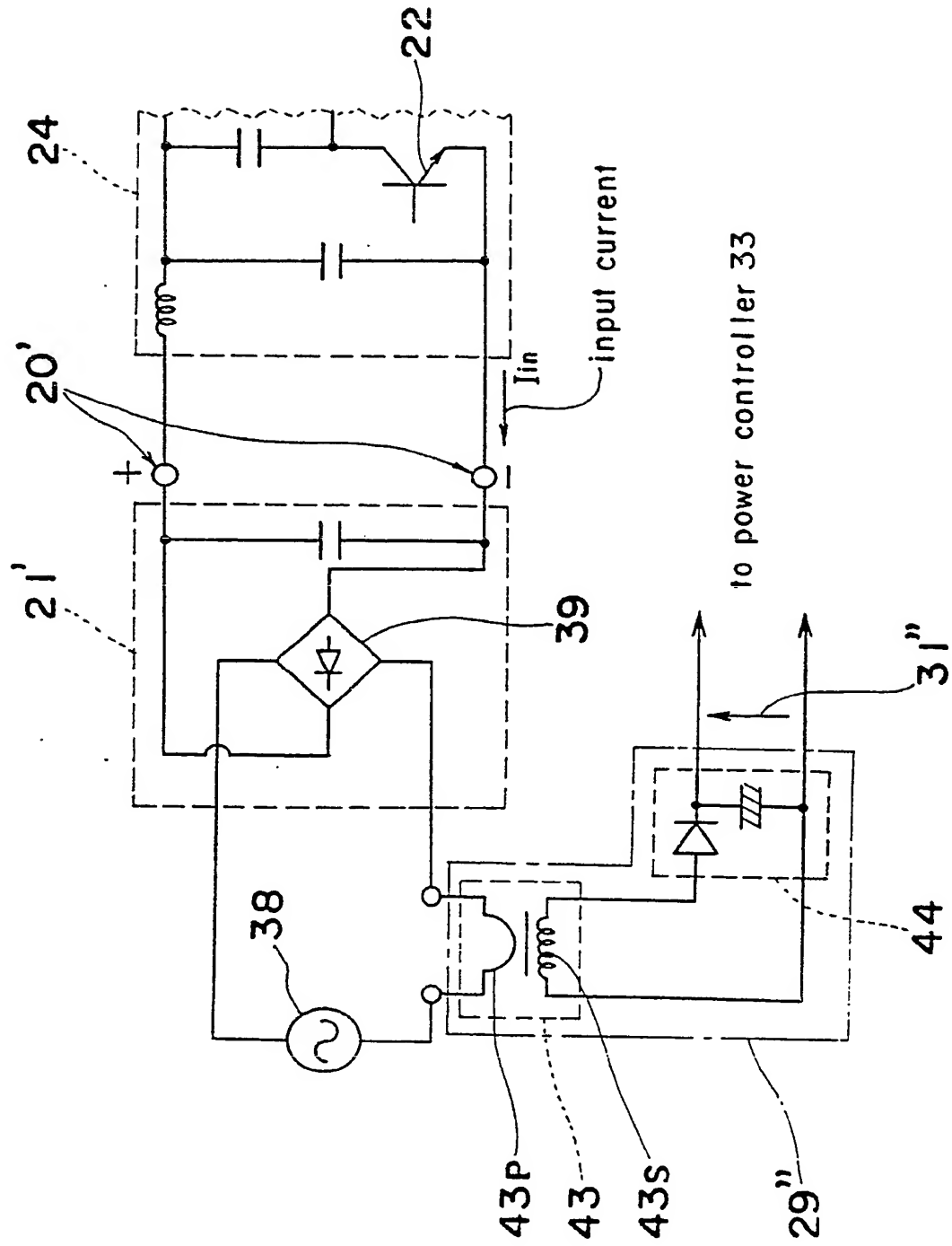


Fig. 9

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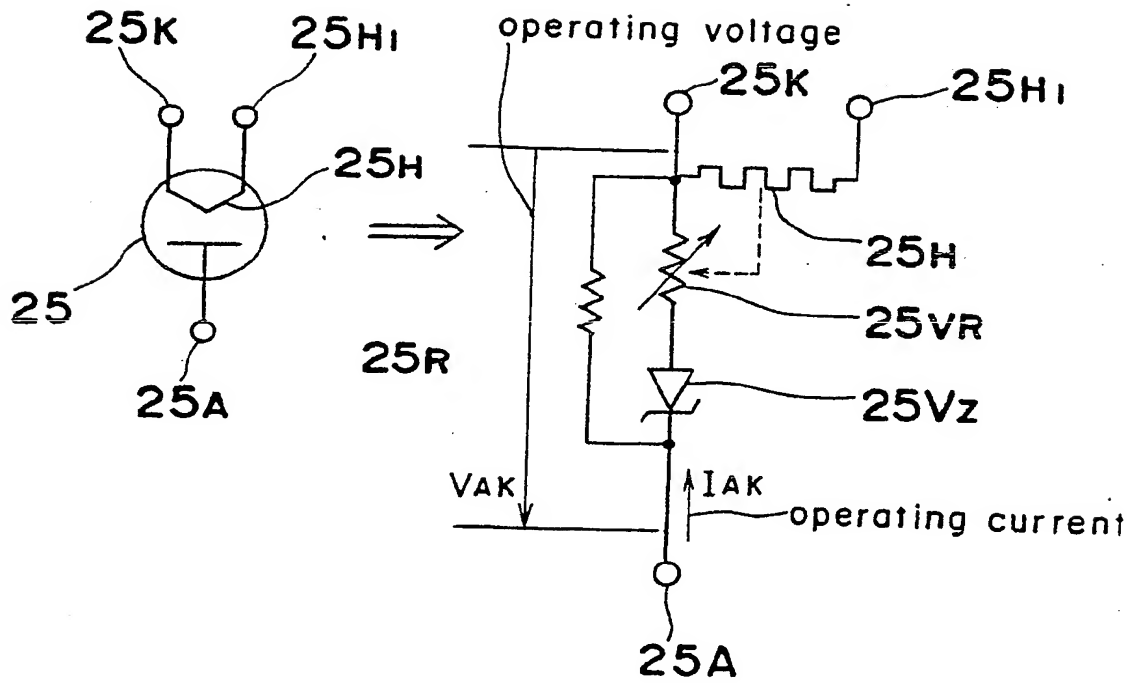
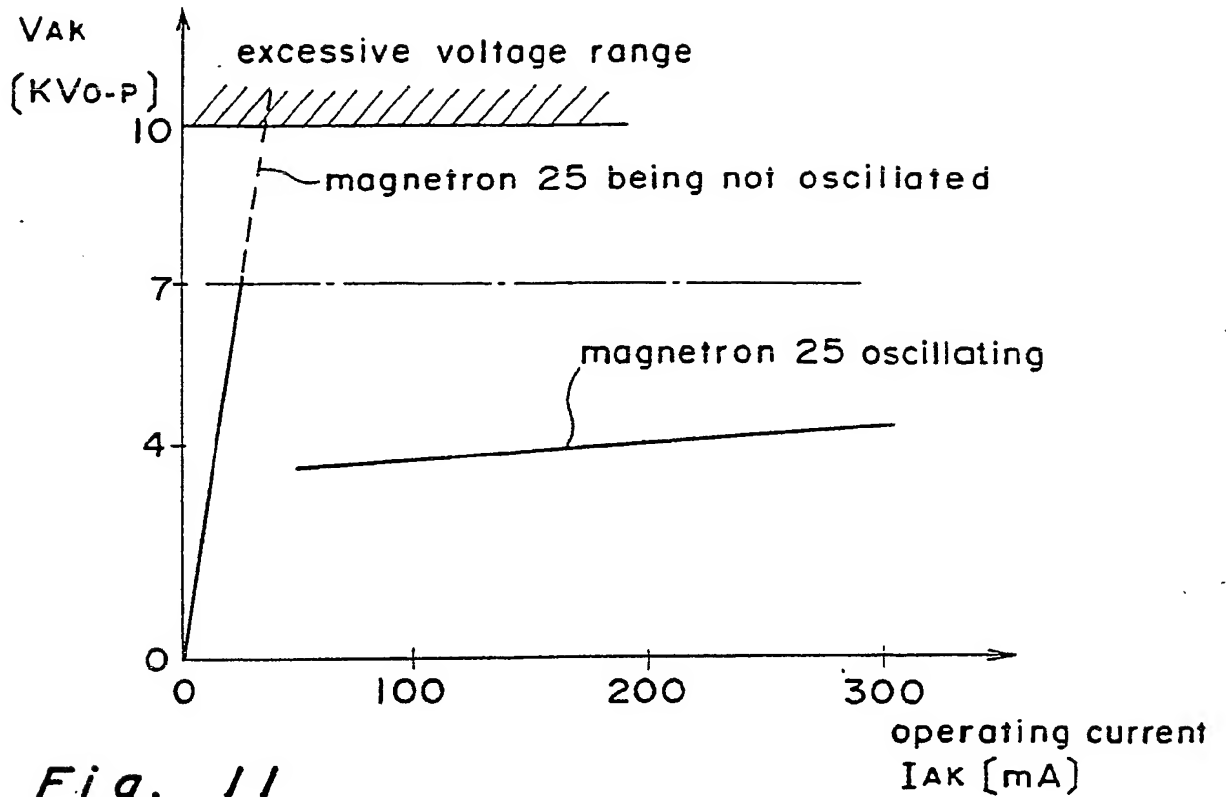
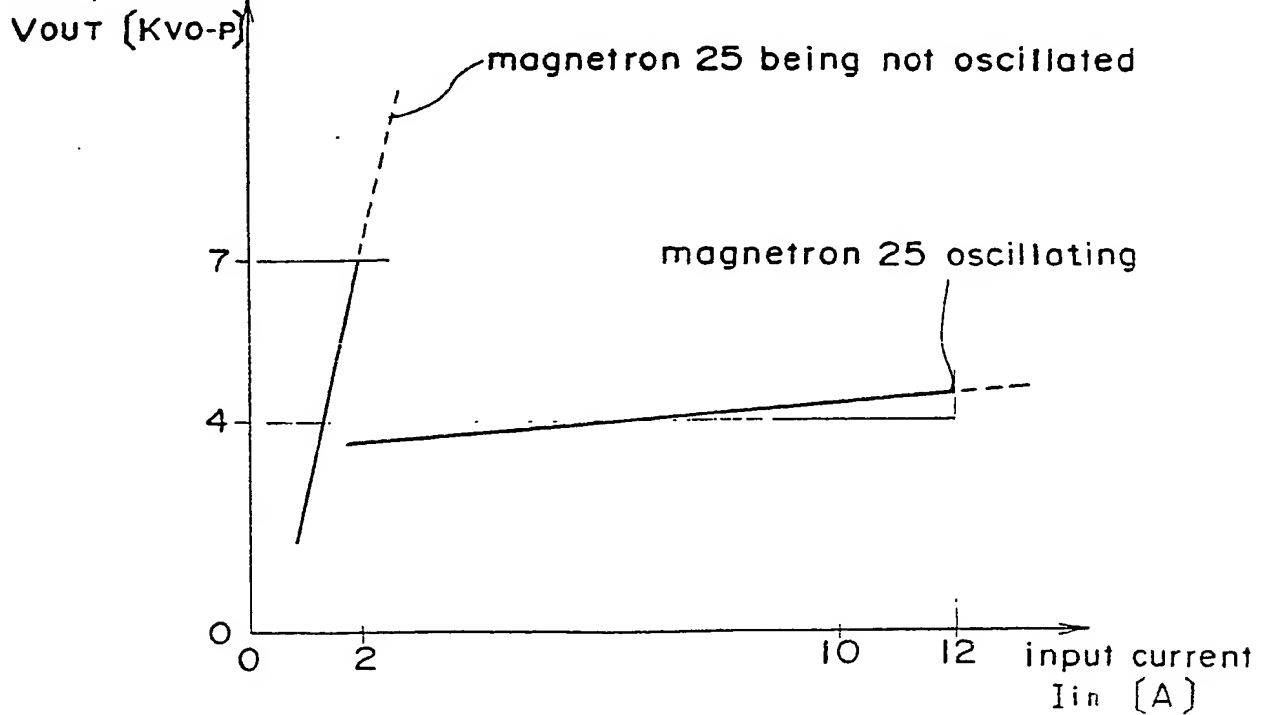


Fig. 10

operating voltage

**Fig. 11**

output voltage



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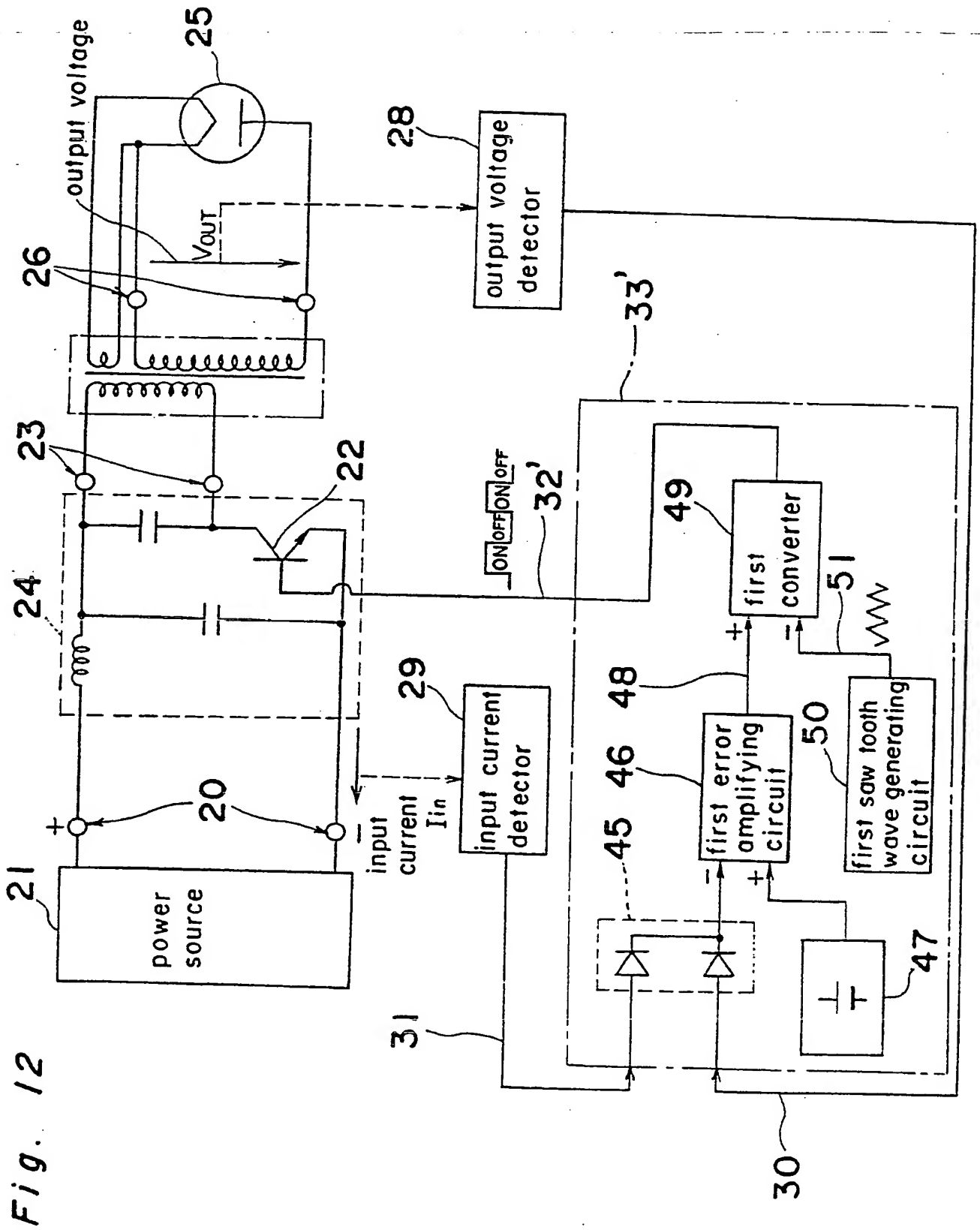


Fig. 13

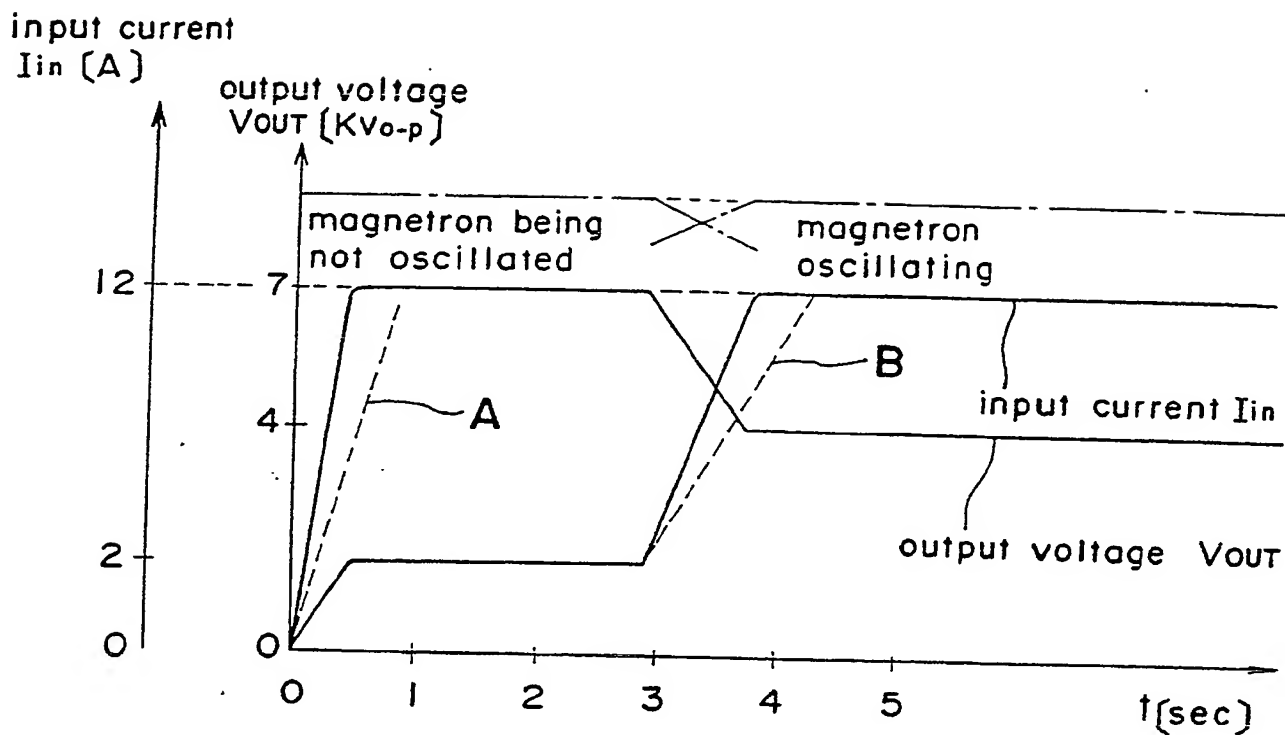
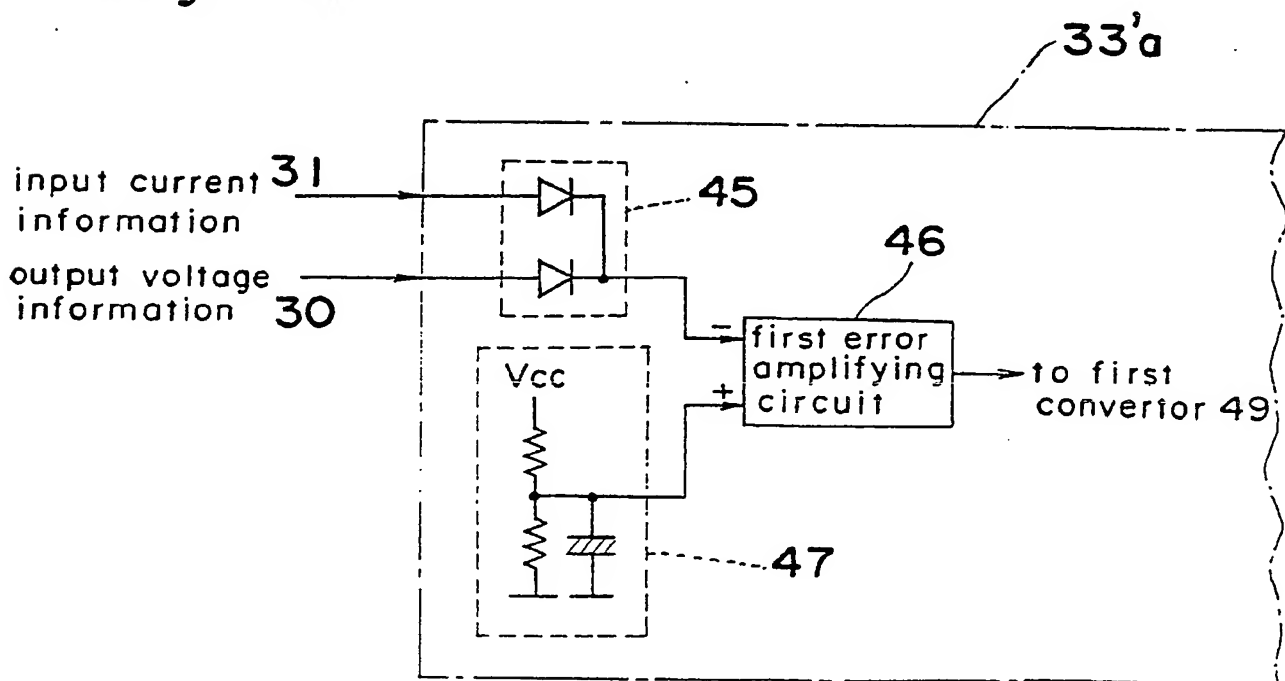


Fig. 14



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Fig. 15

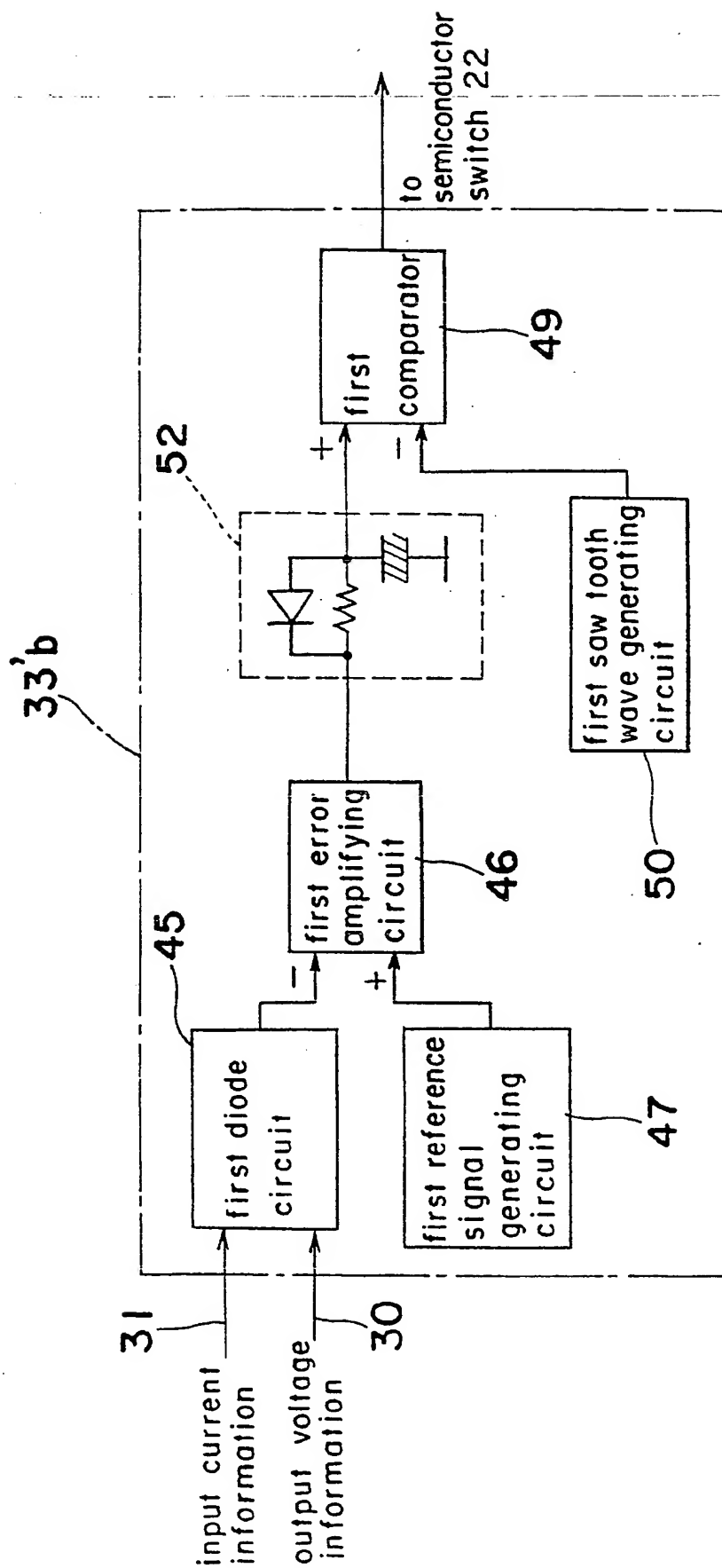
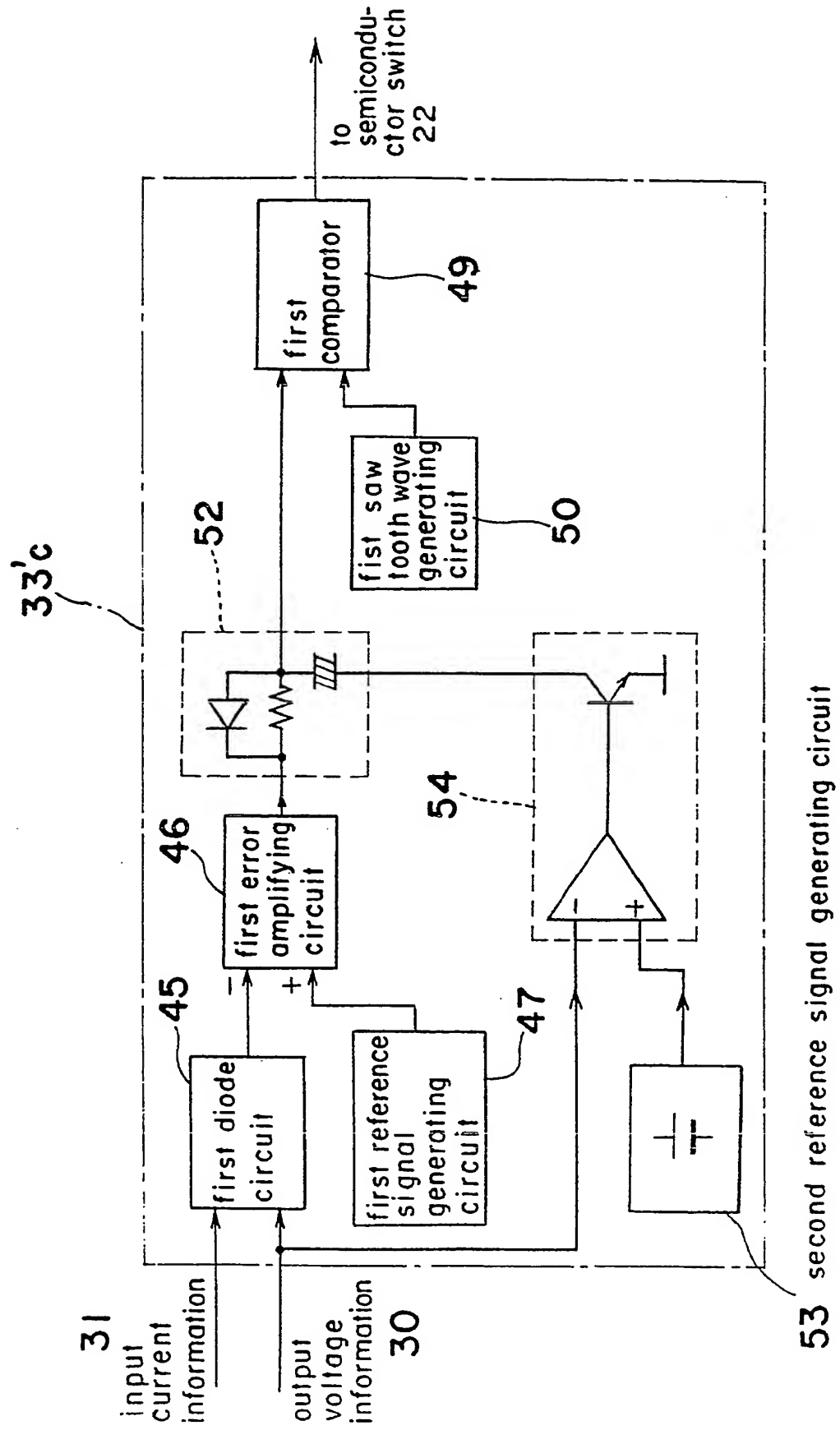


Fig. 16



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Fig. 17

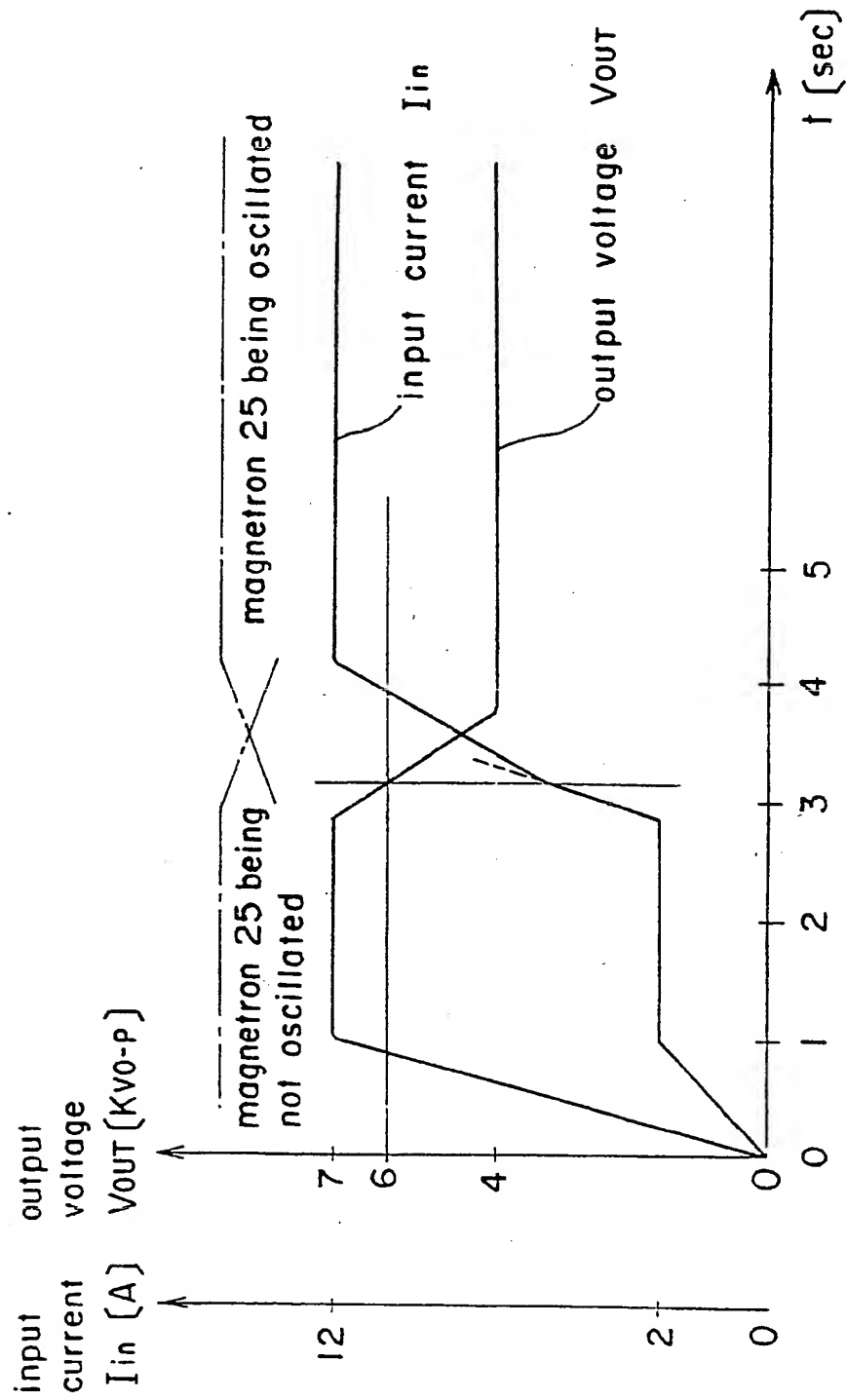
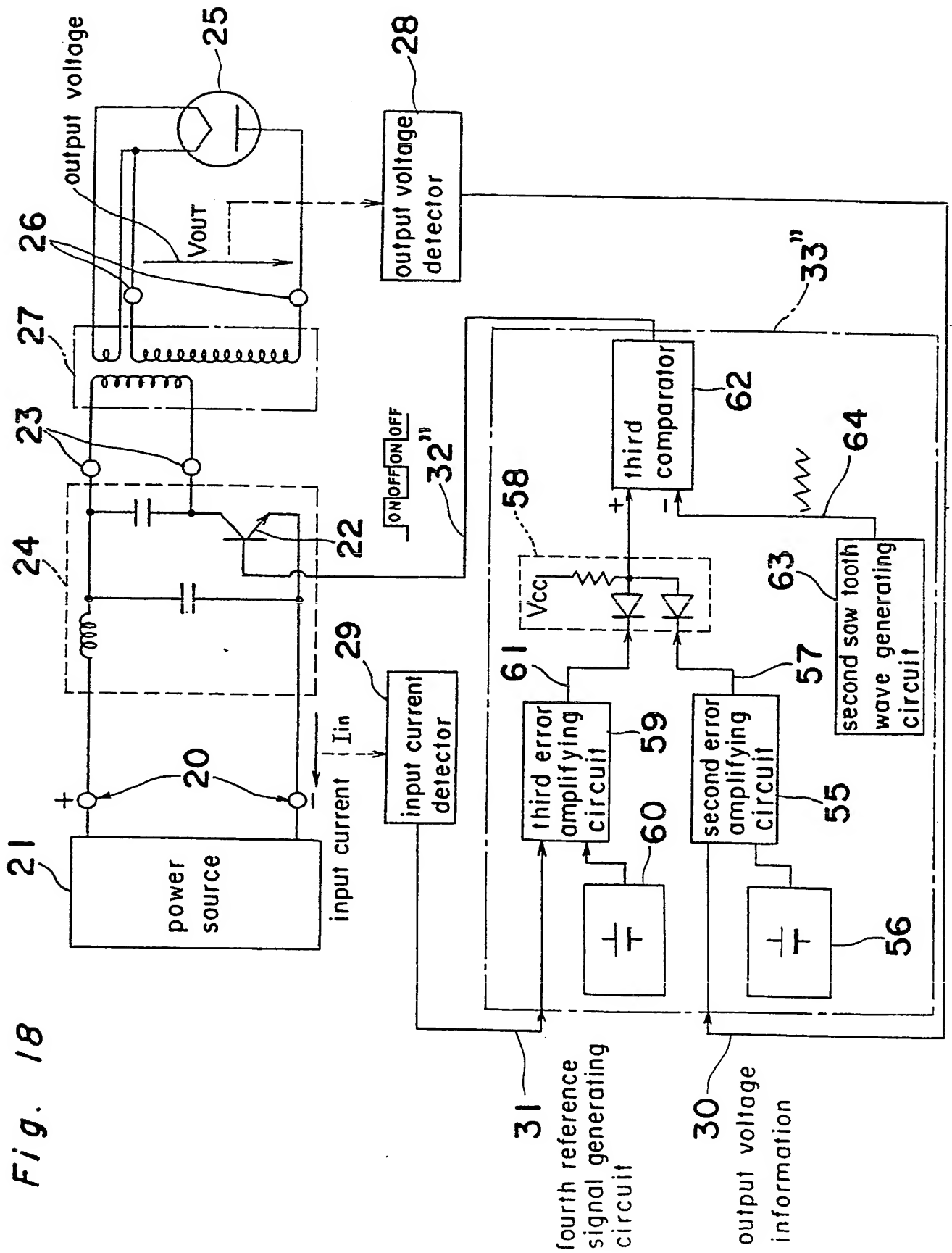


Fig. 18



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Fig. 19

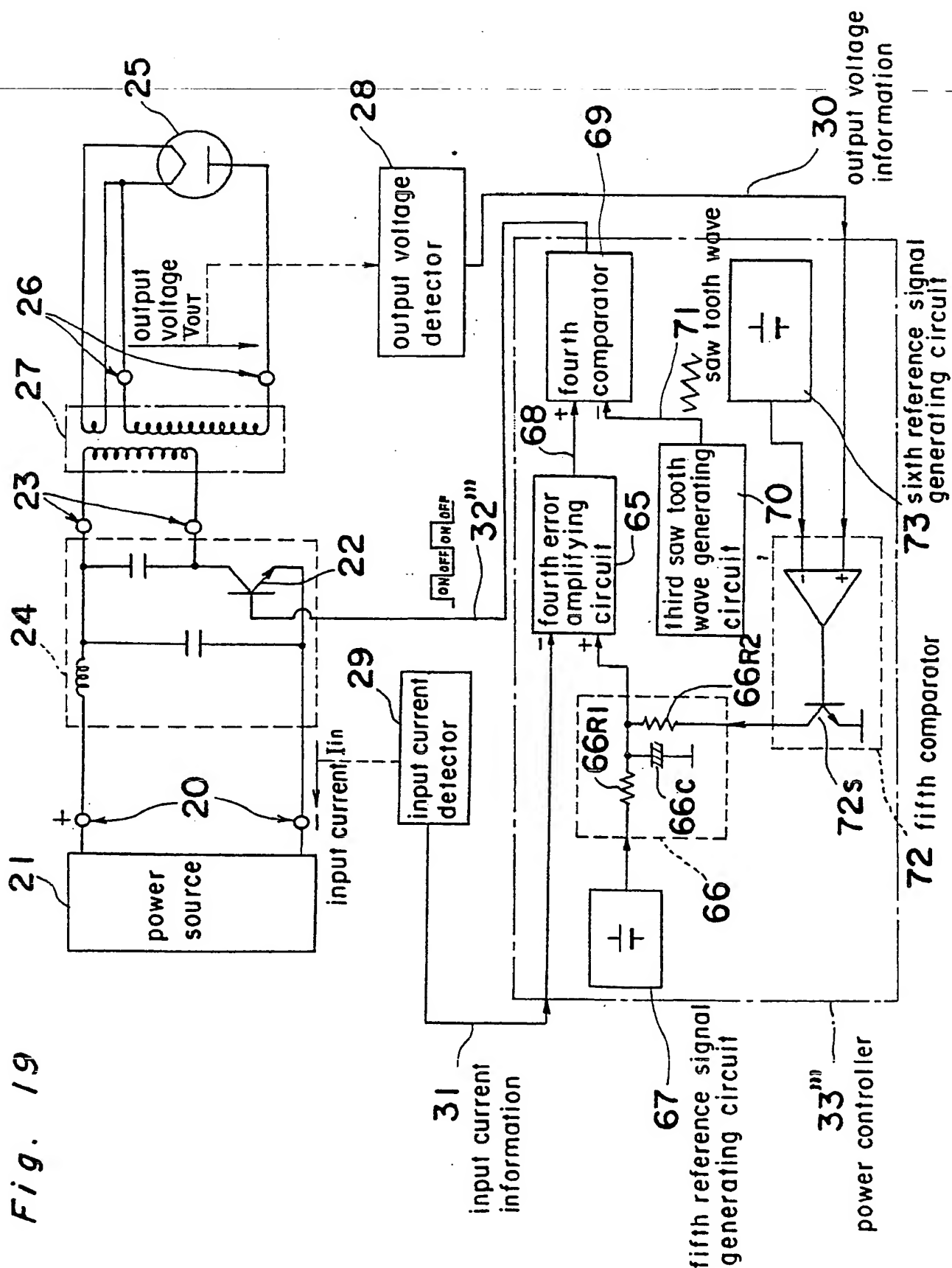
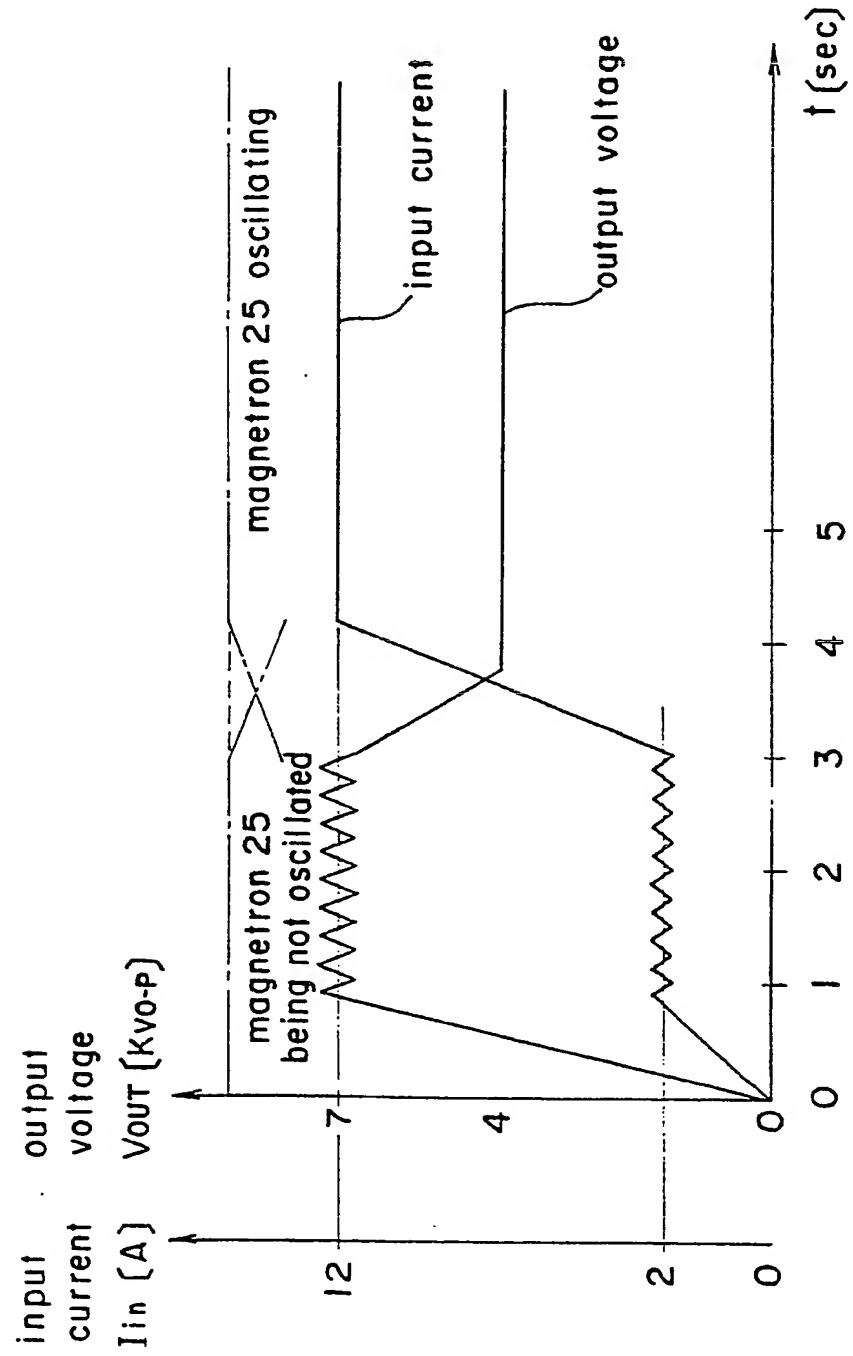
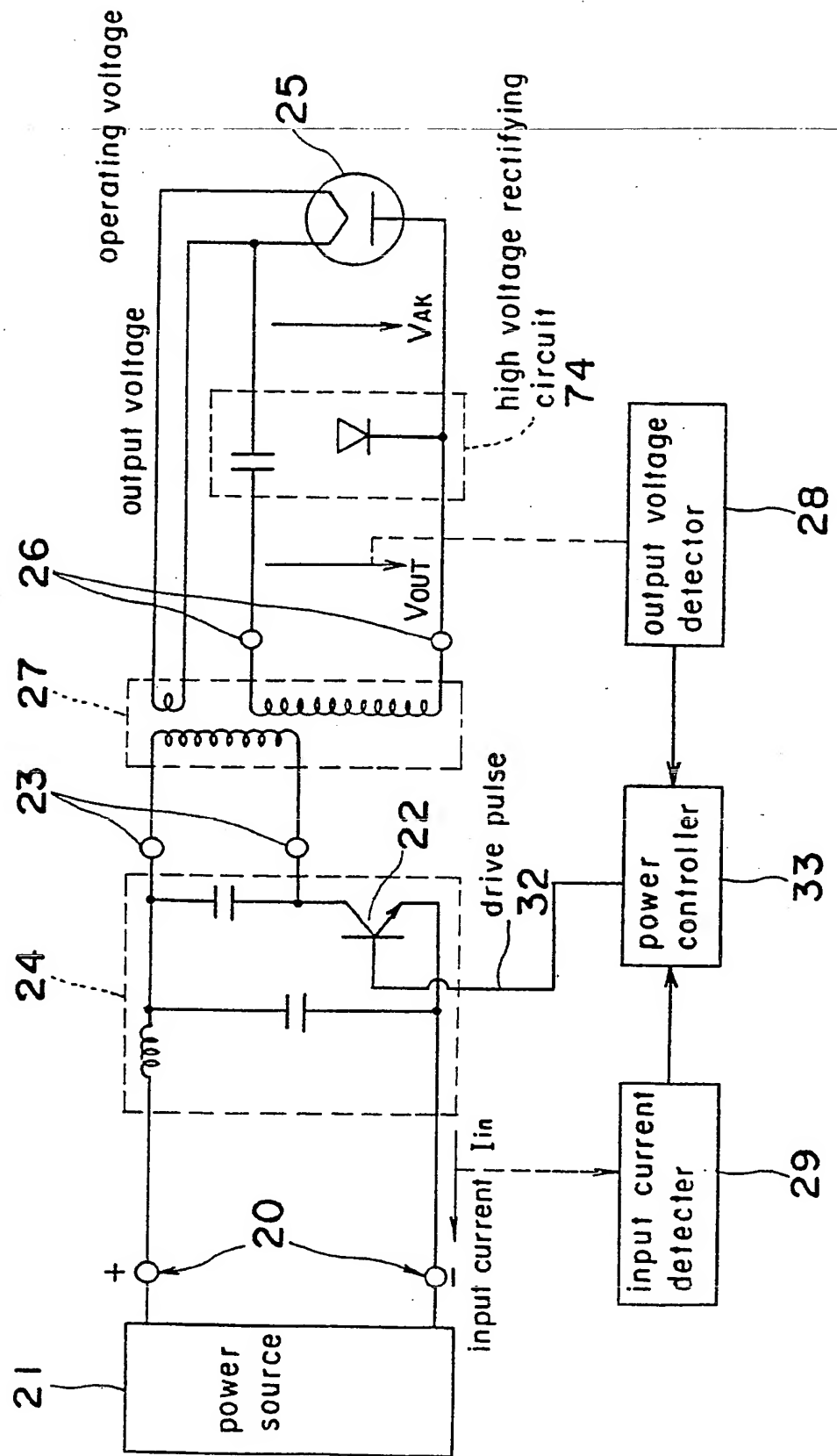


Fig. 20



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Fig. 21



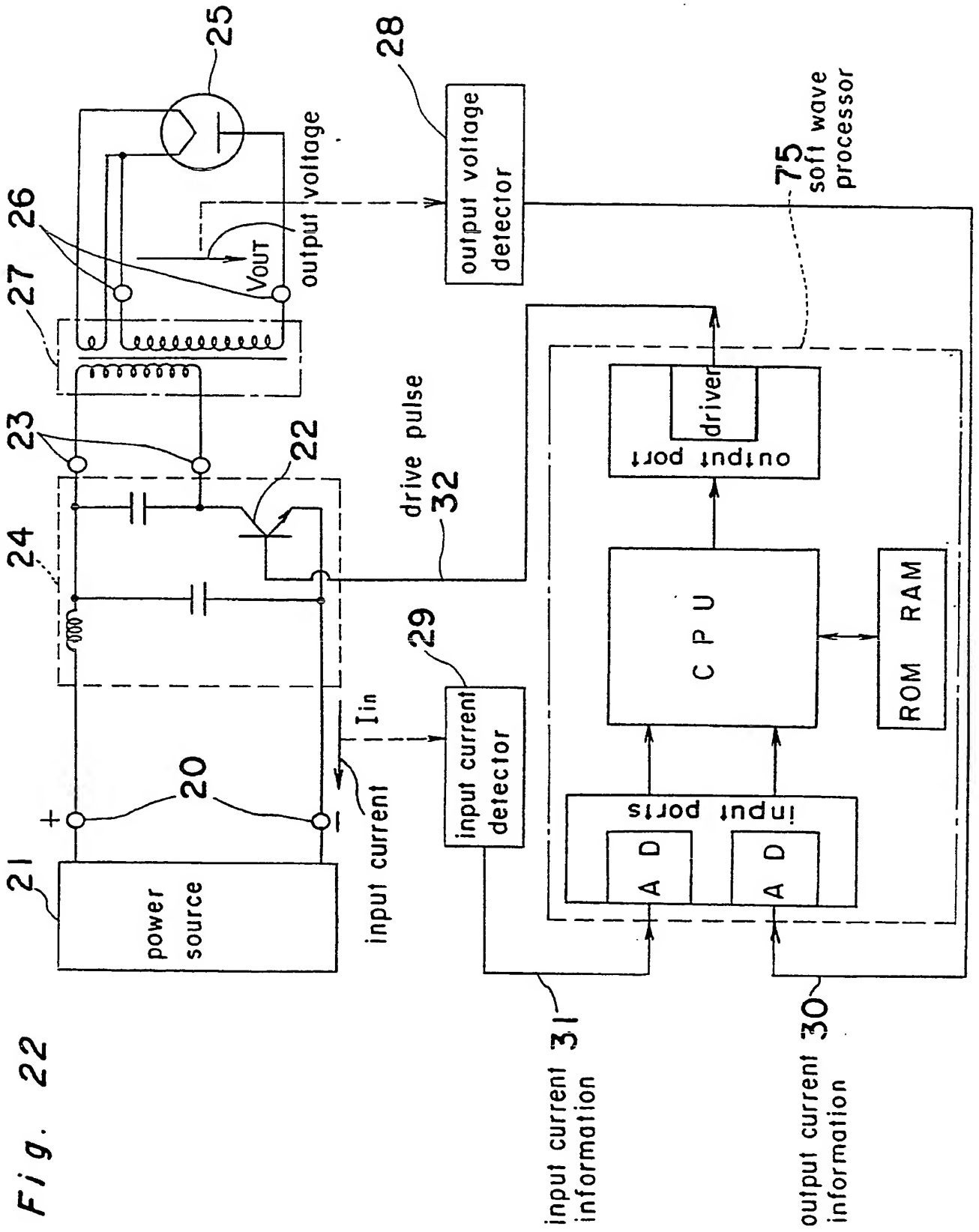
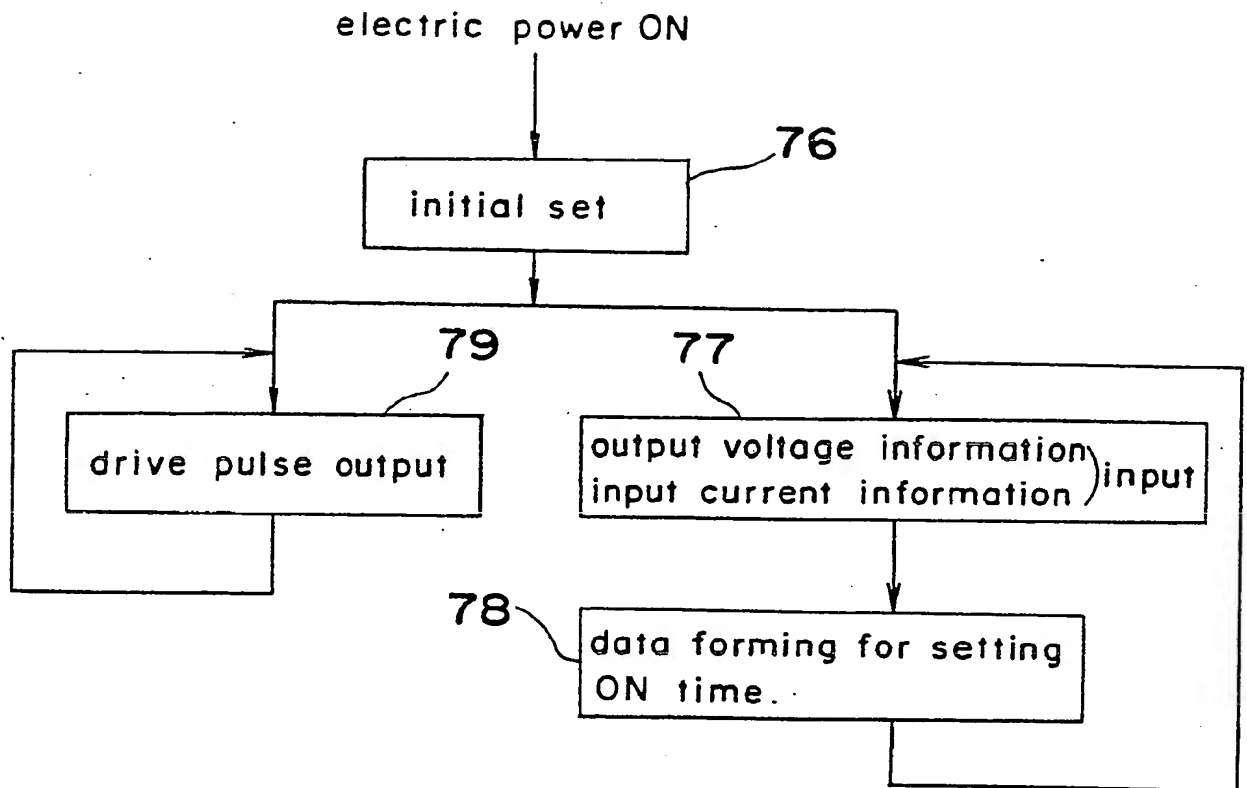


Fig. 23



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Fig. 24

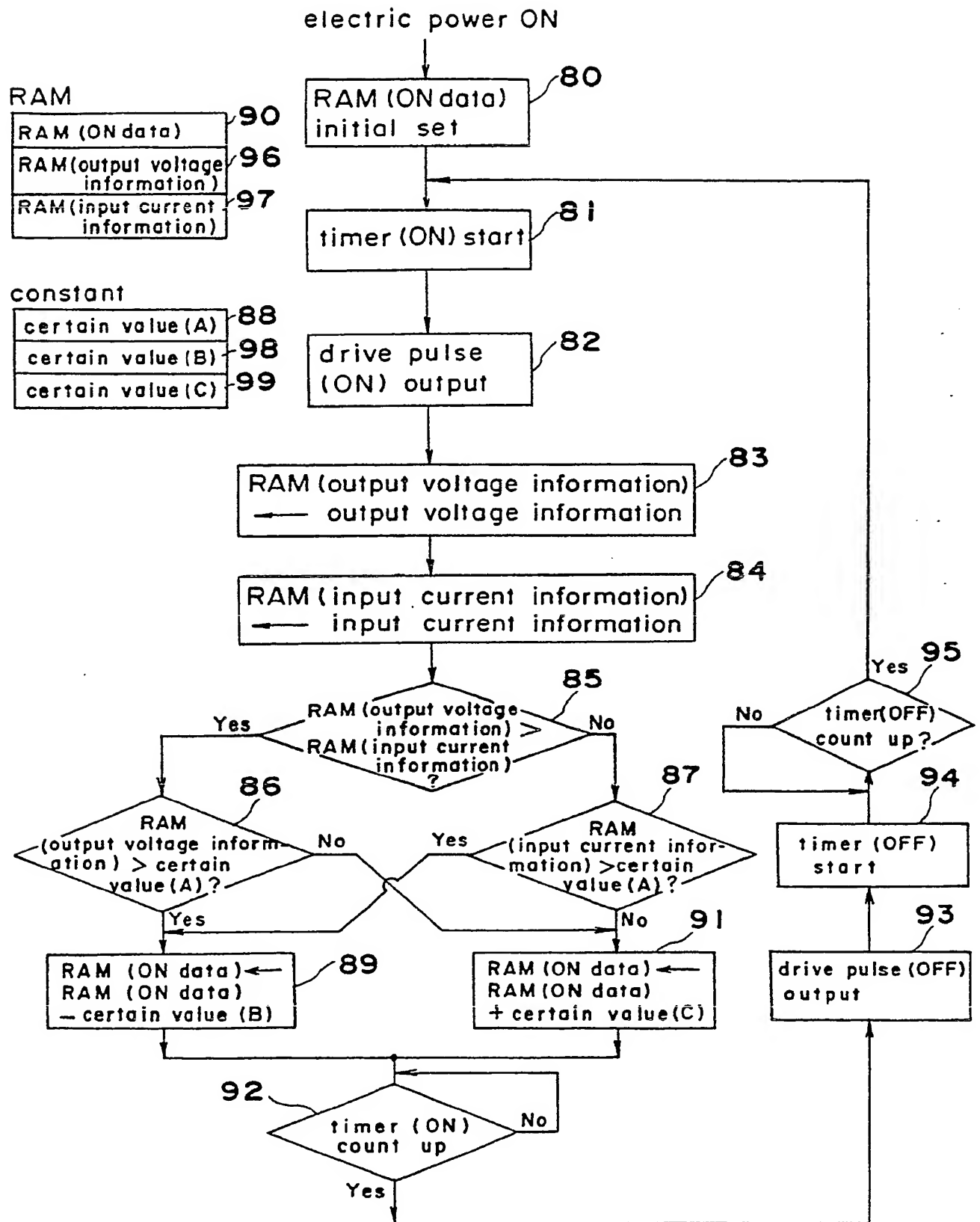


Fig. 25

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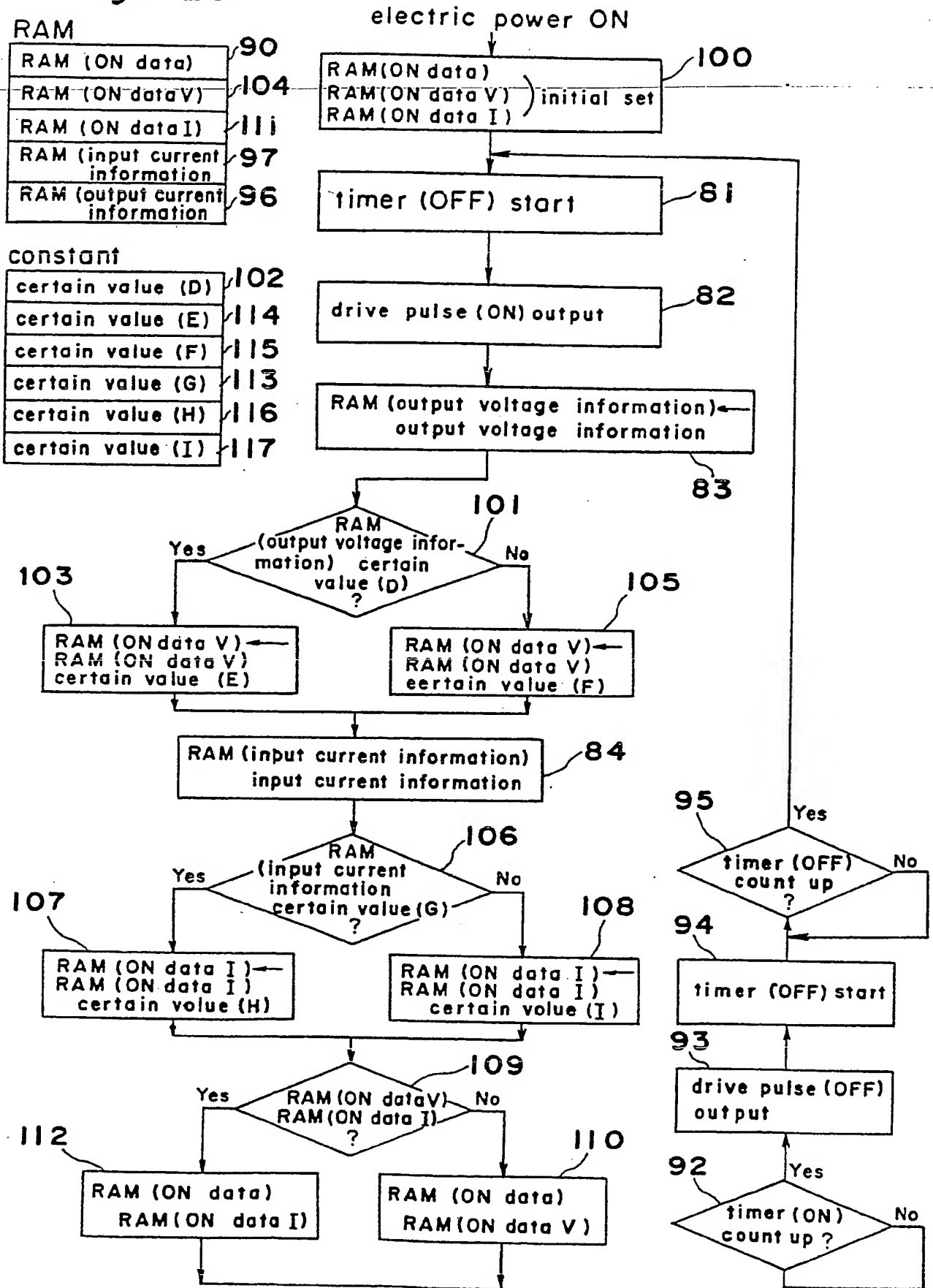
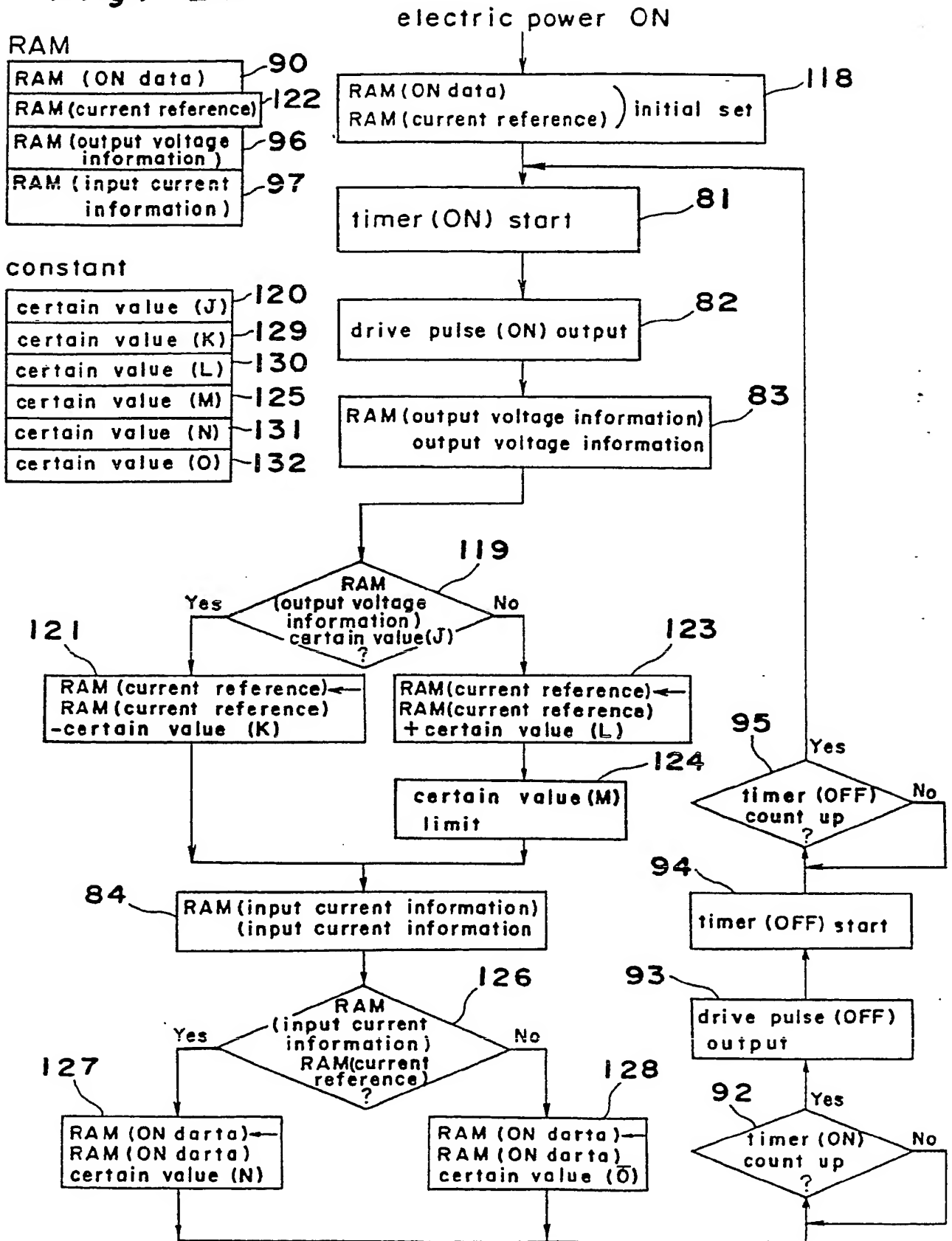


Fig. 26





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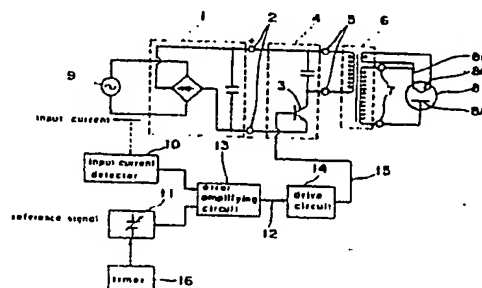
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Magnetron feeding apparatus and method of controlling the same.

A magnetron feeding apparatus and a method of controlling the magnetron feeding apparatus having an inverter circuit for converting the DC power supply into high-frequency power, a high-tension transformer for converting the high-frequency power into the high-tension power to be applied upon the magnetron, an output voltage detecting portion for detecting the output voltage of the high-tension transformer, an input current detecting portion for detecting the input current into the inverter circuit, a power controlling means for controlling the operation of the inverter circuit by the output voltage information of

the output voltage detecting portion and the input current information of the input current detecting portion.



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| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
|---|---|---|---|
| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
| X | US-A-4 318 165 (KORNFUMPF et al.) * Column 1, lines 56-66; column 2, lines 5-22; column 8, lines 45-59; column 9, line 62 - column 10, line 5; figures 1,2 * | 1,7,14 | H 03 B 9/10 H 05 B 6/66 H 02 M 3/335 |
| Y | --- | 4-6,12,13 | |
| Y | FR-A-2 284 976 (MATSUSHITA) * Page 3, lines 32-38; figure 8 * | 4,5,13 | |
| Y | FR-A-2 324 116 (MATSUSHITA ELEC. IND.) * Page 2, lines 31-34; figure 2 * | 6,12 | |
| | | | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| | | | H 02 M H 05 B H 03 B |
| The present search report has been drawn up for all claims | | | |
| Place of search THE HAGUE | | Date of completion of the search 06-11-1989 | Examiner GARDELLA S. |
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